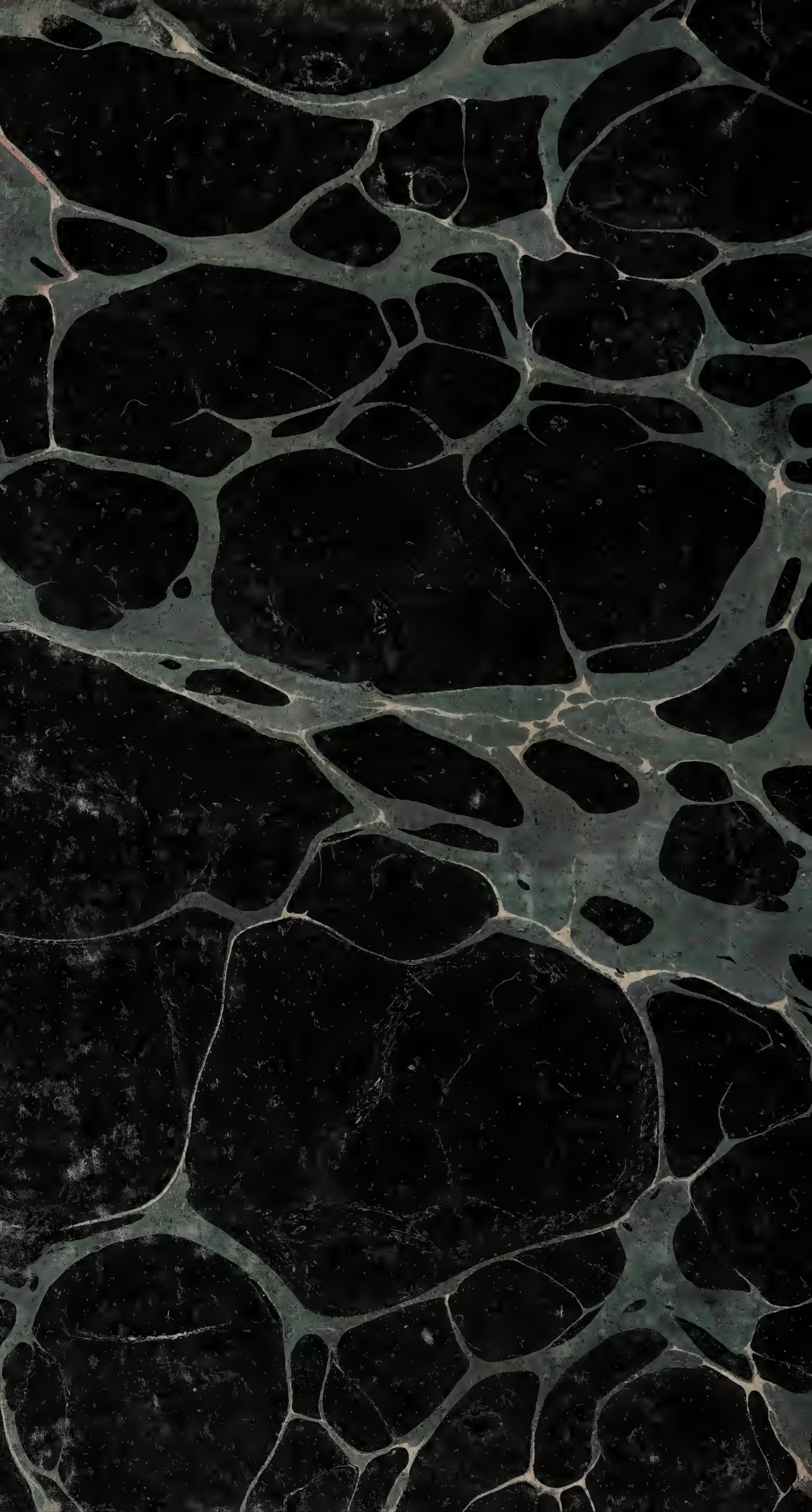

PERET AD ASTRA VIRTUS



AN

HISTORY

OF THE

EARTH,

AND

ANIMATED NATURE:

By OLIVER GOLDSMITH.

IN EIGHT VOLUMES.

VOL. I.

DUBLIN:

PRINTED FOR JAMES WILLIAMS, [No. 21,]
SKINNER-ROW.

MDCC LXXVII.

TO THE RIGHT HONOURABLE

EDMUND SEXTON PERY, Eſq;

SPEAKER OF THE HONOURABLE HOUSE OF COMMONS.

SIR,

I AM happy in an opportunity of paying my reſpects to Your public and private virtues, as well as deſirous to prefix to a favourite work ſo reſpectable a name as that of Mr. PERY. Dr. *Goldſmith*'s Hiſtory of Animated Nature, is a compoſition of the firſt merit; and I offer it to Your peruſal in an Iriſh dreſs, as I am perſuaded You will be pleaſed to ſee an attempt, to remove the reproaches which Ireland has laboured under for bad Printing.

YOU, SIR, know the value of relaxation and retirement from the buſy world; and Mr. PERY is celebrated for his taſte in buildings, gardens, improvements, and agriculture, as well as for his great political endowments and labours in introducing laws which have changed the face of Ireland from a deſart into a land of cultivation: at the ſame time that they made its metropolis the conſumer of native production, which before was the expenſive market for the benefit of foreigners and the depredation of fellow ſubjects.

YOU have not only, SIR, given population to Your country, and plenty to its new inhabitants,

but You have protected the free Cities; of these, that which has the honour to boast of having given You birth, is the most striking instance. Limerick, by Your pains, and at Your expence, has, if I may use the expression, disdained the narrow limits of its antique walls, and covered a large tract of country with buildings of the most elegant texture and appearance, worthy of the noble river which flows near them, and worthy of the magnificent ideas of their Author.

THE usual limits of a Dedication, and the universality of Your private and public character, marked by numberless instances of disinterested friendship, and real patriotism, forbid me to say more on a subject upon which I and every good Irishman could long dwell with pleasure.

PERMIT me, SIR, to profess my profound esteem, and to assure You, that nothing can give me a more sincere felicity, than Your approbation of my well intended endeavours for the public service, in my humble sphere, and of my ambition to subscribe myself,

YOUR MOST

RESPECTFUL ADMIRER,

AND MOST DEVOTED

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BY THE

PRINTER OF THE IRISH EDITION

OF

GOLDSMITH'S HISTORY OF THE EARTH,

TO THE

PUBLIC.

IN every endeavour I have uſed for promoting the Art of Printing in this kingdom, I have met with encouragement beyond my wiſhes; for I may with confidence affirm, that Hume's Hiſtory of England, 8 vols; Archbiſhop Secker's Works, 6 vols; Ruffhead's New and Compleat Law Dictionary; Harris's Hermes; and ſome other valuable books printed by me, are ſuperior to the London Editions. It will, I hope, no longer be ſaid, that our Types are half formed, and our Printing Ink and Paper of any colour but black and white; or that it requires ſpectacles to peruſe the ordinary productions of our Preſſes. Encouragement has animated the ardour of my labours; and I confeſs, that my ambition glows with the probable expectation of ſoon finding my name inrolled with thoſe of *Tonſon*, *Millar*, and *Foulis*; who, at the ſame time that

they have enriched themſelves, and contributed to propagate ſcience, have done honour to their reſpective countries. The preſent Work, which I offer, will (I have no doubt) eſtabliſh the idea of my endeavours, in this effort, to pleaſe the PUBLIC: It is equally correct with the original, printed on a larger Type, and better Paper. The celerity of putting a work of merit, beautifully printed, into every one's hands, (which is my principal deſire,) muſt always draw the applauſe of the learned and curious, ſince we ſee as many fond of a new book to read, as to be the firſt night at a new play. The Animated World is the object of every rational being: Dr. GOLDSMITH's Hiſtory of it, is the firſt work of the kind in point of merit. He has made the ſtudy of it eaſy and familiar. My boaſt is to have repreſented the Doctor in an handſome garb, ſuch as HE deſerves to appear in; I have made more room for him to exhibit in; and I am happy, that thro' me, my Countrymen will be gratified with this charming repaſt.

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PREFACE.

NATURAL HISTORY, conſidered in its utmoſt extent, comprehends two objects. Firſt, that of diſcovering, aſcertaining, and naming all the various productions of nature. Secondly, that of deſcribing the properties, manners, and relations, which they bear to us, and to each other. The firſt, which is the moſt difficult part of this ſcience, is ſyſtematical, dry, mechanical, and incomplete. The ſecond is more amuſing, exhibits new pictures to the imagination, and improves our reliſh for exiſtence, by widening the proſpect of nature around us.

Both, however, are neceſſary to thoſe who would underſtand this

pleaſing ſcience, in its utmoſt extent. The firſt care of every enquirer, no doubt ſhould be, to ſee, to viſit and examine every object, before he pretends to inſpect its habitudes or its hiſtory. From ſeeing and obſerving the thing itſelf, he is moſt naturally led to ſpeculate upon its uſes, its delights, or its inconveniences.

Numberleſs obſtructions, however, are found in this part of his purſuit, that fruſtrate his diligence and retard his curioſity. The objects in nature are ſo many, and even thoſe of the ſame kind are exhibited in ſuch a variety of forms, that the enquirer finds himſelf loſt, in the exuberance before him, and, like a man who attempts to count the ſtars unaſſiſted by art, his powers are all diſtracted in the barren ſuperfluity.

To remedy this embarraſſment, artificial ſyſtems have been deviſed, which grouping into maſſes thoſe parts of nature more nearly reſembling each other, refer the enquirer for

for the name of the ſingle object he deſires to know to ſome one of thoſe general diſtributions, where it is to be found by further examination.

If, for inſtance, a man ſhould, in his walks, meet with an animal, the name, and conſequently the hiſtory of which, he deſires to know, he is taught by ſyſtematic writers of natural hiſtory, to examine its moſt obvious qualities, whether a quadrupede, a bird, a fiſh, or an inſect. Having determined it, for explanation ſake, to be an inſect, he examines whether it has wings; if he finds it poſſeſſed of theſe, he is taught to examine whether it has two or four; if poſſeſſed of four, he is taught to obſerve, whether the two upper wings are of a ſhelly hardneſs, and ſerve as caſes to thoſe under them; if he finds the wings compoſed in this manner, he is then taught to pronounce, that this inſect is one of the beetle kind:

of the beetle kind, there are three different claſſes, diſtinguiſhed from each other by their feelers; he examines the inſect before him, and finds that the feelers are clavated or knobbed at the ends; of beetles, with feelers thus formed, there are ten kinds; and among thoſe, he is taught to look for the preciſe name of that which is before him. If, for inſtance, the knob be divided at the ends, and the belly be ſtreaked with white, it is no other than the Dor or the May-bug; an animal, the noxious qualities of which give it a very diſtinguiſhed rank in the hiſtory of the inſect creation. In this manner a ſyſtem of natural hiſtory may, in ſome meaſure, be compared to a dictionary of words. Both are ſolely intended to explain the names of things; but with this difference, that in the dictionary of words we are led from the name of the thing to its definition; whereas in the ſyſtem of natural hiſtory, we are led from the definition to find out the name. Such

Such are the efforts of writers, who have compoſed their works with great labour and ingenuity, to direct the learner in his progreſs through nature, and to inform him of the name of every animal, plant, or foſſil ſubſtance, that he happens to meet with: but it would be only deceiving the reader, to conceal the truth, which is, that books alone can never teach him this art in perfection; and the ſolitary ſtudent can never ſucceed. Without a maſter, and a previous knowledge of many of the objects in nature, his book will only ſerve to confound and diſguſt him. Few of the individual plants or animals, that he may happen to meet with, are in that preciſe ſtate of health, or that exact period of vegetation, from whence their deſcriptions were taken. Perhaps he meets the plant only with leaves, but the ſyſtematic writer has deſcribed it in flower. Perhaps he meets the bird before it has moulted its firſt feathers, while the ſyſtematic deſcription was

made

made in its ſtate of full perfection. He thus ranges without an inſtructor, confuſed and with ſickening curioſity from ſubject to ſubject, till at laſt he gives up the purſuit, in the multiplicity of his diſappointments.

Some practice therefore, much inſtruction and diligent reading, are requiſite to make a ready and expert naturaliſt, who ſhall be able, even by the help of a ſyſtem, to find out the name of every object he meets with. But when this tedious, though requiſite part of ſtudy is attained, nothing but delight and variety attend the reſt of his journey. Wherever he travels, like a man in a country where he has many friends, he meets with nothing but acquaintances and allurements in all the ſtages of his way. The meer uninformed ſpectator paſſes on in gloomy ſolitude; but the naturaliſt, in every plant, in every inſect, and every pebble, finds ſomething to entertain his curioſity, and excite his ſpeculation.

From

From hence it appears, that a ſyſtem may be conſidered as a dictionary in the ſtudy of nature. The ancients, however, who have all written moſt delightfully on this ſubject, ſeem entirely to have rejected thoſe humble and mechanical helps to ſcience. They contented themſelves with ſeizing upon the great outlines of hiſtory, and paſſing over what was common, as not worth the detail; they only dwelt upon what was new, great, and ſurprizing, and ſometimes even warmed the imagination at the expence of truth. Such of the moderns as revived this ſcience in Europe undertook the taſk more methodically, though not in a manner ſo pleaſing. Aldrovandus, Geſner, and Johnſon, ſeemed deſirous of uniting the entertaining and rich deſcriptions of the ancients with the dry and ſyſtematic arrangement, of which they were the firſt projectors. This attempt, however, was extremely imperfect, as the great variety of nature was, as yet, but very

inadequately

inadequately known. Nevertheleſs, by attempting to carry on both objects at once; firſt, of directing us to the name of the thing; and then giving the detail of its hiſtory, they drew out their works into a tedious and unreaſonable length; and thus mixing incompatible aims they have left their labours, rather to be occaſionally conſulted than read with delight by poſterity.

The later moderns, with that good ſenſe which they have carried into every other part of ſcience, have taken a different method in cultivating natural Hiſtory. They have been content to give, not only the brevity, but alſo the dry and diſguſting air of a dictionary to their ſyſtems. Ray, Klin, Briſſon, and Linnæus, have had only one aim, that of pointing out the object in nature, of diſcovering its name, and where it was to be found in thoſe authors that treated of it in a more prolix and ſatisfactory manner. Thus natural hiſtory at

preſent

preſent is carried on, in two diſtinct and ſeparate channels, the one ſerving to lead us to the thing, the other conveying the hiſtory of the thing, as ſuppoſing it already known.

The following Natural Hiſtory is written, with only ſuch an attention to ſyſtem as ſerves to remove the reader's embarraſſments, and allure him to proceed. It can make no pretenſions in directing him to the name of every object he meets with; that belongs to works of a very different kind, and written with very different aims. It will fully anſwer my deſign, if the reader, being already poſſeſt of the name of any animal, ſhall find here a ſhort, though ſatisfactory hiſtory of its habitudes, its ſubſiſtence, its manners, its friendſhips and hoſtilities. My aim has been to carry on juſt as much method, as was ſufficient to ſhorten my deſcriptions by generalizing them, and never to follow order where the art of writing, which is but another name for good ſenſe, informed

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me that it would only contribute to the reader's embarraſſment.

Still, however, the reader will perceive, that I have formed a kind of ſyſtem in the hiſtory of every part of animated nature, directing myſelf by the great obvious diſtinctions that ſhe herſelf ſeems to have made, which, though too few to point exactly to the name, are yet ſufficient to illuminate the ſubject, and remove the reader's perplexity. Mr. Buffon, indeed, who has brought greater talents to this part of learning than any other man, has almoſt entirely rejected method in claſſing quadrupedes. This, with great deference to ſuch a character, appears to me running into the oppoſite extreme; and, as ſome moderns have of late ſpent much time, great pains, and ſome learning, all to very little purpoſe, in ſyſtematic arrangement, he ſeems ſo much diſguſted by their trifling, but oſtentatious efforts, that he deſcribes his animals, almoſt in the order they happen to come before him.

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This want of method ſeems to be a fault; but he can loſe little by a criticiſm which every dull man can make, or by an error in arrangement, from which the dulleſt are the moſt uſually free.

In other reſpects, as far as this able philoſopher has gone, I have taken him for my guide. The warmth of his ſtyle, and the brilliancy of his imagination, are inimitable. Leaving him therefore without a rival in theſe, and only availing myſelf of his information, I have been content to deſcribe things in my own way; and though many of the materials are taken from him, yet I have added, retrenched, and altered, as I thought proper. It was my intention at one time, whenever I differed from him, to have mentioned it at the bottom of the page; but this occured ſo often, that I ſoon found it would look like envy, and might perhaps, convict me of thoſe very errors which I was wanting to lay upon him. I have therefore, as being every way his debtor,

debtor, concealed my diſſent, where my opinion was different; but wherever I borrow from him, I take care at the bottom of the page to expreſs my obligations. But though my obligations to this writer are many, they extend but to the ſmalleſt part of the work, as he has hitherto compleated only the hiſtory of quadrupedes. I was therefore left to my own reading alone, to make out the hiſtory of birds, fiſhes and inſects, of which the arrangement was ſo difficult, and the neceſſary information ſo widely diffuſed and ſo obſcurely related when found, that it proved by much the moſt laborious part of the undertaking. Thus having made uſe of Mr. Buffon's lights in the firſt part of the work, I may, with ſome ſhare of confidence, recommend it to the public. But what ſhall I ſay to that part, where I have been entirely left without his aſſiſtance? As I would affect neither modeſty nor confidence, it will be ſufficient to ſay, that my reading upon this part of the ſubject has

has been very extenſive; and that I have taxed my ſcanty circumſtances in procuring books which are on this ſubject, of all others, the moſt expenſive. In conſequence of this induſtry, I here offer a work to the public, of a kind, which has never been attempted in ours, or any other modern language, that I know of. The ancients, indeed, and Pliny in particular, have anticipated me, in the preſent manner of treating natural hiſtory. Like thoſe hiſtorians who deſcribe the events of a campaign, they have not condeſcended to give the private particulars of every individual that formed the army; they were content with characterizing the generals, and deſcribing their operations, while they left it to meaner hands to carry the muſter-roll. I have followed their manner, rejecting the numerous fables which they adopted, and adding the improvements of the moderns, which are ſo numerous, that they actually make up the bulk of natural hiſtory.

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The delight which I found in reading Pliny, firſt inſpired me with the idea of a work of this nature. Having a taſte rather claſſical than ſcientific, and having but little employed myſelf in turning over the dry labours of modern ſyſtem-makers, my earlieſt intention was to tranſlate this agreeable writer, and by the help of a commentary to make my work as amuſing as I could. Let us dignify natural hiſtory ever ſo much with the grave appellation of a uſeful ſcience, yet ſtill we muſt confeſs that it is the occupation of the idle and the ſpeculative, more than of the buſy and the ambitious part of mankind. My intention therefore was to treat what I then conceived to be an idle ſubject, in an idle manner; and not to hedge round plain and ſimple narratives with hard words, accumulated diſtinctions, oſtentatious learning, and diſquiſitions that produced no conviction. Upon the appearance however of Mr. Buffon's work, I dropped my former plan, and

adopted

adopted the preſent, being convinced by his manner, that the beſt imitation of the ancients was to write from our own feelings, and to imitate nature.

It will be my chief pride therefore, if this work may be found an innocent amuſement for thoſe who have nothing elſe to employ them, or who require a relaxation from labour. Profeſſed naturaliſts will, no doubt, find it ſuperficial; and yet I ſhould hope that even theſe will diſcover hints, and remarks, gleaned from various reading, not wholly trite or elementary. I would wiſh for their approbation. But my chief ambition is to drag up the obſcure and gloomy learning of the cell to open inſpection; to ſtrip it from its garb of auſterity, and to ſhew the beauties of that form, which only the induſtrious and the inquiſitive have been hitherto permitted to approach.

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AN HISTORY OF THE EARTH.

CHAP. I.

A Sketch of the Univerſe.

THE world may be conſidered as one vaſt manſion, where man has been admitted to enjoy, to admire, and to be grateful. The firſt deſires of ſavage nature are merely to gratify the importunities of ſenſual appetite, and to neglect the contemplation of things, barely ſatisfied with their enjoyment: the beauties of nature, and all the wonders of creation, have but little charms for a being taken up in obviating the wants of the day, and anxious for precarious ſubſiſtence.

Our philoſophers, therefore, who have teſtified ſuch ſurprize at the want of curioſity in the ignorant, ſeem not to conſider that they are uſually employed in making proviſions of a more important nature; in providing rather for the neceſſities than the amuſements of life. It is not till our more preſſing wants are ſufficiently ſupplied, that we can attend to the calls of curioſity; ſo that in every age ſcientific refinement has been the lateſt effort of human induſtry.

But human curioſity, though, at firſt, ſlowly excited, being at laſt poſſeſſed of leiſure for indulging its propenſity, becomes one of the greateſt amuſements of life, and gives higher ſatisfactions than what even the ſenſes can afford. A man of this diſpoſition turns all nature into a magnificent theatre, replete with objects of wonder and ſurprize, and fitted up chiefly for his happineſs and entertainment: he induſtriouſly examines all things, from the minuteſt inſect to the moſt finiſhed animal; and, when his limited organs can no longer make the diſquiſition, he ſends out his imagination upon new enquiries.

Nothing, therefore, can be more auguſt and ſtriking than the idea which his reaſon, aided by his imagination, furniſhes of the

univerſe

univerſe around him. Aſtronomers tell us, that this earth which we inhabit forms but a very minute part in that great aſſemblage of bodies of which the world is compoſed. It is a million of times leſs than the ſun, by which it is enlightened. The planets alſo, which, like it, are ſubordinate to the ſun's influence, exceed the earth one thouſand times in magnitude. Theſe, which were at firſt ſuppoſed to wander in the heavens without any fixed path, and that took their name from their apparent deviations, have long been found to perform their circuits with great exactneſs and ſtrict regularity. They have been diſcovered as forming with our earth a ſyſtem of bodies circulating round the ſun, all obedient to one law, and impelled by one common influence.

Modern philoſophy has taught us to believe, that, when the great Author of nature began the work of creation, he choſe to operate by ſecond cauſes; and, that, ſuſpending the conſtant exertion of his power, he endued matter with a quality by which the univerſal œconomy of nature might be continued without his immediate aſſiſtance. This quality is called *attraction*; a ſort of approximating influence, which all bodies, whether terreſtrial or celeſtial, are found to poſſeſs; and which in all encreaſes as the

quantity of matter in each encreaſes. The ſun, by far the greateſt body in our ſyſtem, is, of conſequence, poſſeſt of much the greateſt ſhare of this attractive power; and all the planets, of which our earth is one, are, of courſe, entirely ſubject to its ſuperior influence. Were this power, therefore, left uncontrolled by any other, the ſun muſt quickly have attracted all the bodies of our celeſtial ſyſtem to itſelf; but it is equably counteracted by another power of equal efficacy; namely, a progreſſive force which each planet received when it was impelled forward, by the divine architect, upon its firſt formation. The heavenly bodies of our ſyſtem being thus acted upon by two oppoſing powers; namely, by that of *attraction*, which draws them towards the ſun; and that of *impulſion*, which drives them ſtrait forward into the great void of ſpace; they purſue a track between theſe contrary directions; and each, like a ſtone whirled about in a ſling, obeying two oppoſite forces, circulates round its great centre of heat and motion.

In this manner, therefore, is the harmony of our planetary ſyſtem preſerved. The ſun, in the midſt, gives heat, and light, and circular motion to the planets which ſurround it: Mercury, Venus, the Earth, Mars, Jupiter,

piter, and Saturn, perform their conſtant circuits at different diſtances, each taking up a time to compleat its revolutions proportioned to the greatneſs of the circle which it is to deſcribe. The leſſer planets alſo, which are attendants upon ſome of the greater, are ſubject to the ſame laws; they circulate with the ſame exactneſs; and are, in the ſame manner, influenced by their reſpective centres of motion.

Beſides thoſe bodies which make a part of our peculiar ſyſtem, and which may be ſaid to reſide within its great circumference; there are others, that frequently come among us, from the moſt diſtant tracts of ſpace, and that ſeem like dangerous intruders upon the beautiful ſimplicity of nature. Theſe are comets, whoſe appearance was once ſo terrible to mankind, and the theory of which is ſo little underſtood at preſent: all we know, is, that their number is much greater than that of the planets; and that, like theſe, they roll in orbits, in ſome meaſure, obedient to Solar influence. Aſtronomers have endeavoured to calculate the returning periods of many of them; but experience has not, as yet, confirmed the veracity of their inveſtigations: indeed, who can tell when thoſe wanderers have made their excurſions into other worlds and diſtant ſyſtems, what obſtacles

obſtacles may be found to oppoſe their progreſs, to accelerate their motions, or retard their return?

But what we have hitherto attempted to ſketch, is but a ſmall part of that great fabric in which the Deity has thought proper to manifeſt his wiſdom and omnipotence. There are multitudes of other bodies diſperſt over the face of the heavens that lie too remote for examination: theſe have no motion, ſuch as the planets are found to poſſeſs, and are, therefore, called fixed ſtars; and from their extreme brilliancy and their immenſe diſtance, philoſophers have been induced to ſuppoſe them to be ſuns reſembling that which enlivens our ſyſtem: as the imagination alſo, once excited, is ſeldom content to ſtop, it has furniſhed each with an attendant ſyſtem of planets belonging to itſelf, and has even induced ſome to deplore the fate of thoſe ſyſtems, whoſe imagined ſuns, which ſometimes happens, have become no longer viſible.

But conjectures of this kind, which no reaſoning can aſcertain, nor experiment reach, are rather amuſing than uſeful. Though we ſee the greatneſs and wiſdom of the Deity in all the ſeeming worlds that ſurround us, it is our chief concern to trace him in that which we inhabit. The examination

nation of the earth, the wonders of its contrivance, the hiſtory of its advantages, or of the ſeeming defects in its formation, are the proper buſineſs of the *natural hiſtorian*. A deſcription of this earth, its *animals*, *vegetables*, and *minerals*, is the moſt delightful entertainment the mind can be furniſhed with, as it is the moſt intereſting and uſeful. I would beg leave, therefore, to conclude theſe common-place ſpeculations, with an obſervation, which, I hope, is not entirely ſo.

An uſe, hitherto not much inſiſted upon, that may reſult from the contemplation of celeſtial magnificence, is, that it will teach us to make an allowance for the apparent irregularities we find below. Whenever we can examine the works of the Deity at a proper point of diſtance, ſo as to take in the whole of his deſign, we ſee nothing but uniformity, beauty, and preciſion. The heavens preſent us with a plan, which, though inexpreſſibly magnificent, is yet regular beyond the power of invention. Whenever, therefore, we find any apparent defects in the earth, which we are about to conſider, inſtead of attempting to reaſon ourſelves into an opinion that they are beautiful, it will be wiſer to ſay, that we do not behold them at the proper point of diſtance, and that our

eye

eye is laid too close to the objects to take in the regularity of their connexion. In short, we may conclude, that God, who is regular in his great productions, acts with equal uniformity in the little.

CHAP. II.

A short Survey of the Globe, from the Light of Astronomy and Geography.

ALL the sciences are in some measure linked with each other, and before the one is ended the other begins. In a natural history, therefore, of the earth, we must begin with a short account of its situation and form, as given us by astronomers and geographers: it will be sufficient, however, upon this occasion, just to hint to the imagination, what they, by the most abstract reasonings, have forced upon the understanding. The earth which we inhabit is, as has been said before, one of those bodies which circulate in our solar system; it is placed at an happy middle distance from the centre; and even seems, in this respect, privileged beyond all other planets that depend upon our great luminary for their support. Less distant from the sun than Saturn, Jupiter, and Mars,

Mars, and yet leſs parched up than Venus and Mercury, that are ſituate too near the violence of its power, the earth ſeems in a peculiar manner to ſhare the bounty of the Creator: it is not, therefore, without reaſon that mankind conſider themſelves as the peculiar objects of his providence and regard.

Beſides that motion which the earth has round the ſun, the circuit of which is performed in a year, it has another upon its own axle, which it performs in twenty-four hours. Thus, like a chariot-wheel, it has a compound motion; for while it goes forward on its journey, it is all the while turning upon itſelf. From the firſt of theſe two ariſe the grateful viciſſitude of the ſeaſons; from the ſecond, that of day and night.

It may be alſo readily conceived, that a body thus wheeling in circles will moſt probably be itſelf a ſphere. The earth, beyond all poſſibility of doubt, is found to be ſo. Whenever its ſhadow happens to fall upon the moon, in an eclipſe, it appears to be always circular, in whatever poſition it is projected: and it is eaſy to prove, that a body which in every poſition makes a circular ſhadow, muſt itſelf be round. The rotundity of the earth may be alſo proved from the meeting of two ſhips at ſea: the

top

top-maſts of each are the firſt parts that are diſcovered by both, the under parts being hidden by the convexity of the globe which riſes between them. The ſhips in this inſtance may be reſembled to two men who approach each other on the oppoſite ſides of an hill: their heads will firſt be ſeen, and gradually as they come nearer they will come entirely into view.

However, though the earth's figure is ſaid to be ſpherical, we ought only to conceive it as being nearly ſo. It has been found in the laſt age to be rather flatted at both poles, ſo that its form is commonly reſembled to that of a turnep. The cauſe of this ſwelling of the equator is aſcribed to the greater rapidity of the motion with which the parts of the earth are there carried round; and which, conſequently, endeavouring to fly off, act in oppoſition to central attraction. The twirling of a mop may ſerve as an homely illuſtration; which, as every one has ſeen, ſpreads and grows broader in the middle as it continues to be turned round.

As the earth receives light and motion from the ſun, ſo it derives much of its warmth and power of vegetation from the ſame beneficent ſource. However, the different parts of the globe participate of theſe advan-

advantages in very different proportions, and accordingly put on very different appearances; a polar proſpect, and a landſcape at the equator, are as oppoſite in their appearances as in their ſituation.

The polar regions, that receive the ſolar beams in a very oblique direction, and that continue for one half of the year in night, receive but few of the genial comforts that other parts of the world enjoy. Nothing can be more mournful or hideous than the picture which travellers preſent of thoſe wretched regions. The ground*, which is rocky and barren, rears itſelf in every place in lofty mountains and inacceſſible cliffs, and meets the mariner's eye at even forty leagues from ſhore. Theſe precipices, frightful in themſelves, receive an additional horror from being conſtantly covered with ice and ſnow, which daily ſeem to accumulate, and to fill all the vallies with encreaſing deſolation. The few rocks and cliffs, that are bare of ſnow, look at a diſtance of a dark brown colour, and quite naked. Upon a nearer approach, however, they are found replete with many different veins of coloured ſtone, and here and there ſpread over with a little earth, and a ſcanty portion of graſs and heath. The internal parts of the

* Crantz's hiſtory of Greenland, p. 3.

country

country are ſtill more deſolate and deterring. In wandering this ſolitude, ſome plains appear covered with ice, that, at firſt glance, ſeem to promiſe the traveller an eaſy journey *. But theſe are even more formidable and more unpaſſable than the mountains themſelves, being cleft with dreadful chaſms, and every where abounding with pits that threaten certain deſtruction. The ſeas that ſurround theſe inhoſpitable coaſts, are ſtill more aſtoniſhing, being covered with flakes of floating ice, that ſpread like extenſive fields, or that riſe out of the water like enormous mountains. Theſe, which are compoſed of materials as clear and tranſparent as glaſs †, aſſume many ſtrange and phantaſtic appearances. Some of them look like churches or caſtles, with pointed turrets; ſome like ſhips in full ſail; and people have often given themſelves the fruitleſs toil to attempt piloting the imaginary veſſels into harbour. There are ſtill others that appear like large iſlands, with plains, valleys, and hills, which often rear their heads two hundred yards above the level of the ſea; and although the height of theſe be amazing, yet their depth beneath is ſtill more ſo; ſome of them being found to ſink three hundred fathom under water.

* Crantz's hiſtory of Greenland, p. 22. † Ibid. 27.

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The earth preſents a very different appearance at the equator, where the ſunbeams, darting directly downwards, burn up the lighter ſoils into extenſive ſandy deſarts, or quicken all the moiſter tracts with incredible vegetation. In theſe regions, almoſt all the ſame inconveniencies are felt from the proximity of the ſun, that in the former were endured from its abſence. The deſarts are entirely barren except where they are found to produce ſerpents, and that in ſuch quantities, that ſome extenſive plains ſeem almoſt entirely covered with them*.

It not unfrequently happens alſo that this dry ſoil, which is ſo parched and comminuted by the force of the ſun, riſes with the ſmalleſt breeze of wind; and the ſands being compoſed of parts almoſt as ſmall as thoſe of water, they aſſume a ſimilar appearance, rolling onward in waves like thoſe of a troubled ſea, and overwhelming all they meet with inevitable deſtruction. On the other hand, thoſe tracts which are fertile, teem with vegetation even to a noxious degree. The graſs riſes to ſuch an height as often to require burning; the foreſts are impaſſable from underwoods, and ſo matted above, that even the ſun, fierce as it is, can ſeldom penetrate†. Theſe are ſo thick as

* Adanſon's Deſcription of Senegal.

† Linnæi Amænit. vol. vi. p. 67.

ſcarce

ſcarce to be extirpated; for the tops being ſo bound together by the climbing plants that grow round them, though an hundred ſhould be cut at the bottom, yet not one would fall, as they mutually ſupport each other. In theſe dark and tangled foreſts, beaſts of various kinds, inſects in aſtoniſhing abundance, and ſerpents of ſurprizing magnitude, find a quiet retreat from man, and are ſeldom diſturbed except by each other.

In this manner the extremes of our globe ſeem equally unfitted for the comforts and conveniencies of life; and, although the imagination may find an awful pleaſure in contemplating the frightful precipices of Greenland, or the luxurious verdure of Africa, yet true happineſs can only be found in the more moderate climates, where the gifts of nature may be enjoyed without incurring danger in obtaining them.

It is in the temperate zone, therefore, that all the arts of improving nature, and refining upon happineſs, have been invented: and this part of the earth is, more properly ſpeaking, the theatre of natural hiſtory. Although there be millions of animals and vegetables in the unexplored foreſts under the line, yet moſt of theſe may for ever continue unknown, as curioſity is there repreſſed by ſur-

ſurrounding danger. But it is otherwiſe in theſe delightful regions which we inhabit, and where this art has had its beginning. Among us there is ſcarce a ſhrub, a flower, or an inſect, without its particular hiſtory; ſcarce a plant that could be uſeful that has not been propagated; nor a weed that could be noxious which has not been pointed out.

CHAP. III.

A View of the Surface of the Earth.

WHEN we take a ſlight ſurvey of the ſurface of our globe, a thouſand objects offer themſelves, which, though long known, yet ſtill demand our curioſity. The moſt obvious beauty that every where ſtrikes the eye is the verdant covering of the earth, which is formed by an happy mixture of herbs and trees of various magnitudes and uſes. It has been often remarked that no colour refreſhes the ſight ſo well as green; and it may be added, as a further proof of the aſſertion, that the inhabitants of thoſe places where the fields are continually white with ſnow, generally become blind long before the uſual courſe of nature.

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This advantage, which ariſes from the verdure of the fields, is not a little improved by their agreeable inequalities. There is ſcarce two natural landſcapes that offer proſpects entirely reſembling each other; their riſings and depreſſions, their hills and valleys, are never entirely the ſame, but always offer ſomething new to entertain and refreſh the imagination.

But to encreaſe the beauties of the face of nature, the landſcape is enlivened by ſprings and lakes, and interſected by rivulets. Theſe lend a brightneſs to the proſpect; give motion and coolneſs to the air; and, what is much more important, furniſh health and ſubſiſtence to animated nature.

Such are the moſt obvious and tranquil objects that every where offer: but there are others of a more awful and magnificent kind; the *Mountain* riſing above the clouds, and topt with ſnow; the *River* pouring down its ſides, encreaſing as it runs, and loſing itſelf, at laſt, in the ocean; the *Ocean* ſpreading its immenſe ſheet of waters over one half of the globe, ſwelling and ſubſiding at well-known intervals, and forming a communication between the moſt diſtant parts of the earth.

If we leave thoſe objects that ſeem to be natural to our earth, and keep the ſame conſtant

ſtant tenor, we are preſented with the great irregularities of nature. The burning mountain; the abrupt precipice; the unfathomable cavern; the headlong cataract; and the rapid whirlpool.

If we carry our curioſity a little further, and deſcend to the objects immediately below the ſurface of the globe, we ſhall there find wonders ſtill as amazing. We firſt perceive the earth for the moſt part lying in regular beds or layers, every bed growing thicker in proportion as it lies deeper, and its contents more compact and heavy. We ſhall find, almoſt wherever we make our ſubterranean enquiry, an amazing number of ſhells that once belonged to aquatic animals. Here and there, at a diſtance from the ſea, beds of oyſter-ſhells, ſeveral yards thick, and many miles over; ſometimes teſtaceous ſubſtances of various kinds on the tops of mountains, and often in the heart of the hardeſt marble. Theſe, which are dug up by the peaſants, in every country, are regarded with little curioſity; for being ſo very common, they are conſidered as ſubſtances entirely terrene. But it is otherwiſe with the enquirer after nature, who finds them, not only in ſhape but in ſubſtance, every way reſembling thoſe that are

bred in the ſea; and he, therefore, is at a loſs to account for their removal.

Yet not one part of nature alone, but all her productions and varieties, become the object of the ſpeculative man's enquiry: he takes different views of nature from the inattentive ſpectator; and ſcarce an appearance, how common ſoever, but affords matter for his contemplation: he enquires how and why the ſurface of the earth has come to have thoſe riſings and depreſſions which moſt men call natural; he demands in what manner the mountains were formed, and in what conſiſt their uſes; he aſks from whence ſprings ariſe; and how rivers flow round the convexity of the globe; he enters into an examination of the ebbings and flowings, and the other wonders of the deep; he acquaints himſelf with the irregularities of nature, and he will endeavour to inveſtigate their cauſes; by which, at leaſt, he will become better verſed in their hiſtory. The internal ſtructure of the globe becomes an object of his curioſity; and, although his enquiries can fathom but a very little way, yet, if poſſeſt with a ſpirit of theory, his imagination will ſupply the reſt. He will endeavour to account for the ſituation of the marine foſſils that are found in the earth, and for the appearance of the different beds

of

of which it is compoſed. Theſe have been the enquiries that have ſplendidly employed many of the philoſophers of the laſt and preſent age *; and, to a certain degree, they muſt be ſerviceable. But the worſt of it is, that, as ſpeculations amuſe the writer more than facts, they may be often carried to an extravagant length; and that time may be ſpent in reaſoning upon nature, which might be more uſefully employed in writing her hiſtory.

Too much ſpeculation in natural hiſtory is certainly wrong; but there is a defect of an oppoſite nature that does much more prejudice; namely, that of ſilencing all enquiry, by alledging the benefits we receive from a thing, inſtead of inveſtigating the cauſe of its production. If I enquire how a mountain came to be made, ſuch a reaſoner, enumerating its benefits, anſwers, becauſe God knew it would be uſeful. If I demand the cauſe of an earthquake, he finds ſome good produced by it, and alledges that as the cauſe of its exploſion. Thus ſuch an enquirer has conſtantly ſome ready reaſon for every appearance in nature, which ſerves to ſwell his periods, and give ſplendor to

* Buffon, Woodward, Burnet, Whiſton, Kircher, Bourquat, Leibnitz, Steno, Ray, &c.

his declamation: every thing about him is, on ſome account or other, declared to be good, and he thinks it preſumption to ſcrutinize into its defects, or to endeavour to imagine how it might be better. Such writers, and there are many ſuch, add very little to the advancement of knowledge; and it is finely remarked by Bacon, that the inveſtigation of final cauſes * is a barren ſtudy; and, like a virgin dedicated to the Deity, brings forth nothing. In fact, thoſe men who want to compel every appearance and every irregularity in nature into our ſervice, and expatiate on their benefits, combat that very morality which they would ſeem to promote. God has permitted thouſands of natural evils to exiſt in the world, becauſe it is by their intervention that man is capable of moral evil; and he has permitted that we ſhould be ſubject to moral evil, that we might do ſomething to deſerve eternal happineſs by ſhewing that we had rectitude to avoid it.

* Inveſtigatio cauſarum finalium ſterilis eſt, et veluti virgo Deo dedicata, nil parit.

CHAP.

CHAP. IV.

A Review of the different Theories of the Earth.

HUMAN invention has been exerciſed for ſeveral ages to account for the various irregularities of the earth. While thoſe philoſophers mentioned in the laſt chapter ſee nothing but beauty, ſymmetry, and order; there are others, who look upon the gloomy ſide of nature, enlarge on its defects, and ſeem to conſider the earth, on which they tread, as one ſcene of extenſive deſolation *. Beneath its ſurface they obſerve minerals and waters confuſedly jumbled together; its different beds of earth irregularly lying upon each other; mountains riſing from places that once were level †; and hills ſinking into vallies; whole regions ſwallowed by the ſea, and others again riſing out of its boſom: all theſe they ſuppoſe to be but a few of the changes that have been wrought in our globe; and they ſend out imagination to deſcribe it in its primæval ſtate of beauty.

Of thoſe who have written theories deſcribing the manner of the original formation

* Buffon's ſecond diſcourſe.

† Senec. Quæſt. lib. vi. cap. 21.

of

of the earth, or accounting for its preſent appearances, the moſt celebrated are Burnet, Whiſton, Woodward, and Buffon. As ſpeculation is endleſs, ſo it is not to be wondered that all theſe differ from each other, and give oppoſite accounts of the ſeveral changes, which they ſuppoſe our earth to have undergone. As the ſyſtems of each have had their admirers, it is, in ſome meaſure, incumbent upon the natural hiſtorian to be acquainted, at leaſt, with their outlines; and, indeed, to know what others have even dreamed, in matters of ſcience, is very uſeful, as it may often prevent us from indulging ſimilar deluſions ourſelves, which we ſhould never have adopted, but becauſe we take them to be wholly our own. However, as entering into a detail of theſe theories, is rather furniſhing an hiſtory of opinions than things, I will endeavour to be as conciſe as I can.

The firſt who formed this amuſement of earth-making into ſyſtem was the celebrated Thomas Burnet, a man of polite learning and rapid imagination. His *Sacred Theory*, as he calls it, deſcribing the changes which the earth has undergone, or ſhall hereafter undergo, is well known for the warmth with which it is imagined, and the weakneſs with which it is reaſoned, for the elegance of its

ſtyle,

ſtyle, and the meanneſs of its philoſophy. The earth, ſays he, before the deluge, was very differently formed from what it is at preſent: it was at firſt a fluid maſs; a chaos compoſed of various ſubſtances, differing both in denſity and figure: thoſe which were moſt heavy ſunk to the center, and formed in the middle of our globe an hard ſolid body; thoſe of a lighter nature remained next; and the waters, which were lighter ſtill, ſwam upon its ſurface, and covered the earth on every ſide. The air, and all thoſe fluids which were lighter than water, floated upon this alſo; and in the ſame manner encompaſſed the globe; ſo that between the ſurrounding body of waters, and the circumambient air, there was formed a coat of oil, and other unctuous ſubſtances, lighter than water. However, as the air was ſtill extremely impure, and muſt have carried up with it many of thoſe earthly particles with which it once was intimately blended, it ſoon began to defecate, and to depoſe theſe particles upon the only ſurface already mentioned, which ſoon uniting together, the earth and oil formed that cruſt, which ſoon became an habitable ſurface, giving life to vegetation, and dwelling to animals.

This imaginary antideluvian abode was very

very different from what we ſee it at preſent. The earth was light and rich; and formed of a ſubſtance entirely adapted to the feeble ſtate of incipient vegetation: it was an uniform plain, every where covered with verdure; without mountains, without ſeas, or the ſmalleſt inequalities. It had no difference of ſeaſons, for its equator was in the plain of the ecliptic, or, in other words, it turned directly oppoſite to the ſun, ſo that it enjoyed one perpetual and luxuriant ſpring. However, this delightful face of nature did not long continue the ſame, for, after a time, it began to crack and open in fiſſures; a circumſtance which always ſucceeds when the ſun dries away the moiſture from rich or marſhy ſituations. The crimes of mankind had been for ſome time preparing to draw down the wrath of Heaven; and they, at length, induced the Deity to defer repairing theſe breaches in nature. Thus the chaſms of the earth every day became wider, and, at length, they penetrated to the great abyſs of waters; and the whole earth, in a manner, fell in. Then enſued a total diſorder in the uniform beauty of the firſt creation, the terrene ſurface of the globe being broken down: as it ſunk the waters guſhed out into its place; the deluge became univerſal; all mankind except eight perſons were puniſhed

with

with deſtruction, and their poſterity condemned to toil upon the ruins of deſolated nature.

It only remains to mention the manner in which he relieves the earth from this univerſal wreck, which would ſeem to be as difficult as even its firſt formation. "Theſe great maſſes of earth falling into the abyſs, drew down with them vaſt quantities alſo of air; and by daſhing againſt each other, and breaking into ſmall parts by the repeated violence of the ſhock, they, at length, left between them large cavities filled with nothing but air. Theſe cavities, naturally offered a bed to receive the influent waters; and in proportion as they filled, the face of the earth became once more viſible. The higher parts of its broken ſurface, now become the tops of mountains, were the firſt that appeared; the plains ſoon after came forward, and, at length, the whole globe was delivered from the waters, except the places in the loweſt ſituations; ſo that the ocean and the ſeas are ſtill a part of the ancient abyſs that have not had a place to return. Iſlands and rocks are fragments of the earth's former cruſt; kingdoms and continents are larger maſſes of its broken ſubſtance; and all the inequalities that are to be found on the ſurface of the preſent earth, are owing

to

to the accidental confuſion into which both earth and waters were then thrown.

The next theoriſt was Woodward, who, in his Eſſay towards a Natural Hiſtory of the Earth, which was only deſigned to precede a greater work, has endeavoured to give a more rational account of its appearances; and was, in fact, much better furniſhed for ſuch an undertaking than any of his predeceſſors, being one of the moſt aſſiduous naturaliſts of his time. His little book, therefore, contains many important facts, relative to natural hiſtory, although his ſyſtem may be weak and groundleſs.

He begins by aſſerting that all terrene ſubſtances are diſpoſed in beds of various natures, lying horizontally one over the other, ſomewhat like the coats of an onion; that they are replete with ſhells, and other productions of the ſea: theſe ſhells being found in the deepeſt cavities, and on the tops of the higheſt mountains. From theſe obſervations, which are warranted by experience, he proceeds to obſerve, that theſe ſhells and extraneous foſſils are not productions of the earth, but are all actual remains of thoſe animals which they are known to reſemble; that all the beds of the earth lie under each other, in the order of their ſpecific gravity; and that they are diſpoſed as if they had been left there by ſubſiding waters. All theſe

aſſertions

aſſertions he affirms with much earneſtneſs, although daily experience contradicts him in ſome of them; particularly we find layers of ſtone often over the lighteſt ſoils, and the ſofteſt earth under the hardeſt bodies. However, having taken it for granted, that all the layers of the earth are found in the order of their ſpecific gravity, the lighteſt at the top, and the heavieſt next the centre, he conſequently aſſerts, and it will not improbably follow, that all the ſubſtances of which the earth is compoſed, were once in an actual ſtate of diſſolution. This univerſal diſſolution he takes to have happened at the time of the flood. He ſuppoſes that at that time a body of water, which was then in the center of the earth, uniting with that which was found on the ſurface, ſo far ſeparated the terrene parts as to mix all together in one fluid maſs; the contents of which afterwards ſinking according to their reſpective gravities, produced the preſent appearancee of the earth. Being aware, however, of an objection that foſſile ſubſtances are not found diſſolved, he exempts them from this univerſal diſſolution, and, for that purpoſe, endeavours to ſhew that the parts of animals have a ſtronger coheſion than thoſe of minerals; and that, while even the hardeſt rocks may be diſſolved, bones and ſhells may ſtill continue entire.

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So much for Woodward; but of all the ſyſtems which were publiſhed reſpecting the earth's formation, that of Whiſton was moſt applauded, and moſt oppoſed. Nor need we wonder; for being ſupported with all the parade of deep calculation, it awed the ignorant, and produced the approbation of ſuch as would be thought otherwiſe, as it implied a knowledge of abſtruſe learning, to be even thought capable of comprehending what the writer aimed at. In fact, it is not eaſy to diveſt it of its mathematical garb; but thoſe who have had leiſure, have found the reſult of our philoſopher's reaſoning to be thus. He ſuppoſes the earth to have been originally a comet; and he conſiders the hiſtory of the creation, as given us in ſcripture, to have its commencement juſt when it was taken by the hand of the Creator, to be more regularly placed as a planet in our ſolar ſyſtem. Before that time, he ſuppoſes it to have been a globe without beauty or proportion; a world in diſorder; ſubject to all the viciſſitudes which comets endure; ſome of which have been found, at different times, a thouſand times hotter than melted iron; at others, a thouſand times colder than ice. Theſe alternations of heat and cold, continually melting and freezing the ſurface of the earth, he ſuppoſes to have produced, to

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a certain depth, a chaos entirely reſembling that deſcribed by the poets, ſurrounding the ſolid contents of the earth, which ſtill continued unchanged in the midſt, making a great burning globe of more than two thouſand leagues in diameter. This ſurrounding chaos, however, was far from being ſolid: he reſembles it to a denſe though fluid atmoſphere, compoſed of ſubſtances mingled, agitated, and ſhocked againſt each other; and in this diſorder he deſcribes the earth to have been juſt at the eve of creation.

But upon its orbit's being then changed, when it was more regularly wheeled round the ſun, every thing took its proper place; every part of the ſurrounding fluid then fell into a ſituation, in proportion as it was light or heavy. The middle, or central part, which always remained unchanged, ſtill continued ſo, retaining a part of that heat which it received in its primæval approaches towards the ſun; which heat, he calculates, may continue for about ſix thouſand years. Next to this fell the heavier parts of the chaotic atmoſphere, which ſerve to ſuſtain the lighter: but as in deſcending they could not entirely be ſeparated from many watery parts, with which they were intimately mixed, they drew down a part of theſe alſo with them; and theſe could not mount again after

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the ſurface of the earth was conſolidated: they, therefore, ſurrounded the heavy firſt deſcending parts, in the ſame manner as theſe ſurround the central globe. Thus the entire body of the earth is compoſed moſt internally of a great burning globe: next which, is placed an heavy terrene ſubſtance, that encompaſſes it; round which alſo is circumfuſed a body of water. Upon this body of waters, the cruſt of earth on which we inhabit is placed: ſo that, according to him, the globe is compoſed of a number of coats, or ſhells, one within the other, all of different denſities. The body of the earth being thus formed, the air, which is the lighteſt ſubſtance of all, ſurrounded its ſurface; and the beams of the ſun darting through, produced that light which, we are told, firſt obeyed the Creator's command.

The whole œconomy of the creation being thus adjuſted, it only remained to account for the riſings and depreſſions on the ſurface of the earth, with the other ſeeming irregularities of its preſent appearance. The hills and vallies are conſidered by him as formed by their preſſing upon the internal fluid, which ſuſtains the outward ſhell of earth, with greater or leſs weight: thoſe parts of the earth which are heavieſt, ſink into the ſubjacent fluid more deeply, and become vallies:

vallies: thoſe that are lighteſt, riſe higher upon the earth's ſurface, and are called mountains.

Such was the face of nature before the deluge; the earth was then more fertile and populous than it is at preſent; the life of man and animals was extended to ten times its preſent duration; and all theſe advantages aroſe from the ſuperior heat of the central globe, which ever ſince has been cooling. As its heat was then in its full power, the genial principle was alſo much greater than at preſent; vegetation and animal encreaſe were carried on with more vigour; and all nature ſeemed teeming with the ſeeds of life. But theſe phyſical advantages were only productive of moral evil; the warmth which invigorated the body encreaſed the paſſions and appetites of the mind; and, as man became more powerful, he grew leſs innocent. It was found neceſſary to puniſh his depravity; and all living creatures, except the fiſhes, who living in a cold element were not ſubject to a ſimilitude of guilt, were overwhelmed by the deluge in univerſal deſtruction.

This deluge, which ſimple believers are willing to aſcribe to a miracle, philoſophers have long been deſirous to account for by natural

natural cauſes: they have proved that the earth could never ſupply from any reſervoir towards its center, nor the atmoſphere by any diſcharge from above, ſuch a quantity of water as would cover the ſurface of the globe to a certain depth over the tops of our higheſt mountains. Where, therefore, was all this water to be found? Whiſton has found enough, and more than a ſufficiency, in the tail of a comet; for he ſeems to allot comets a very active part in the great operations of nature.

He calculates, with great ſeeming preciſion, the year, the month, and the day of the week on which this comet (which has paid the earth ſome viſits ſince, though at a kinder diſtance) involved our globe in its tail. The tail he ſuppoſed to be a vaporous fluid ſubſtance, exhaled from the body of the comet, by the extreme heat of the ſun, and encreaſing in proportion as it approached that great luminary. It was in this that our globe was involved at the time of the deluge; and, as the earth ſtill acted by its natural attraction, it drew to itſelf all the watery vapours which were in the comet's tail; and the internal waters being alſo at the ſame time let looſe, in a very ſhort ſpace the tops of the higheſt mountains were laid under the deep.

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The punishment of the deluge being thus compleated, and all the guilty destroyed, the earth, which had been broken by the eruption of the internal waters, was also enlarged by the same; so that upon the comet's recess, there was found room sufficient in the internal abyss for the recess of the superfluous waters; whither they all retired, and left the earth uncovered, but in some respects changed, particularly in its figure, which, from being round, was now become oblate. In this universal wreck of nature Noah survived, by a variety of happy causes, to re-people the earth, and to give birth to a race of men slow in believing ill-imagined theories of the earth.

After so many theories of the earth, which had been published, applauded, answered, and forgotten, Mr. Buffon ventured to add one more to the number. This philosopher was, in every respect, better qualified than any of his predecessors for such an attempt, being furnished with more materials, having a brighter imagination to find new proofs, and a better style to cloath them in. However, if one so ill qualified, as I am, may judge, this seems the weakest part of his admirable work; and I could wish, that he had been content with giving us facts instead of systems; that, instead of being a reasoner,

he had contented himſelf with being merely an hiſtorian.

He begins his ſyſtem by making a diſtinction between the firſt part of it and the laſt; the one being founded only on conjecture, the other depending entirely upon actual obſervation. The latter part of his theory may, therefore, be true, though the former ſhould be found erroneous.

The planets, ſays he, and the earth, among the number, might have been formerly (he only offers this as conjecture) a part of the body of the ſun, and adherent to its ſubſtance. In this ſituation, a comet falling in upon that great body might have given it ſuch a ſhock, and ſo ſhaken its whole frame, that ſome of its particles might have been driven off like ſtreaming ſparkles from red hot iron; and each of theſe ſtreams of fire, ſmall as they were in compariſon of the ſun, might have been large enough to have made an earth as great, nay many times greater than ours. So that in this manner the planets, together with the globe which we inhabit, might have been driven off from the body of the ſun by an impulſive force: in this manner alſo they would continue to recede from it for ever, were they not drawn back by its ſuperior power of attraction; and

thus,

thus, by the combination of the two motions, they are wheeled round in circles.

Being in this manner detached at a diſtance from the body of the ſun, the planets, from having been at firſt globes of liquid fire, gradually became cool. The earth alſo having been daſhed obliquely forward, received a rotatory motion upon its axis at the very inſtant of its formation, and this motion being greateſt at the equator, the parts there acting againſt the force of gravity, they muſt have ſwollen out, and given the earth an oblate or flatted figure.

As to its internal ſubſtance, our globe having once belonged to the ſun, it continues to be an uniform maſs of melted matter, very probably vitrified in its primæval fuſion. But its ſurface is very differently compoſed. Having been in the beginning heated to a degree equal to, if not greater than what comets are found to ſuſtain; like them it had an atmoſphere of vapours floating round it, and which cooling by degrees, condenſed and ſubſided upon its ſurface. Theſe vapours formed, according to their different denſities, the earth, the water, and the air; the heavier parts falling firſt, and the lighter remaining ſtill ſuſpended.

Thus far our philoſopher is, at leaſt, as much a ſyſtem maker as Whiſton or Burnet; and, indeed, he fights his way with great perſeverance and ingenuity through a thouſand objections that naturally ariſe. Having, at laſt, got upon the earth, he ſuppoſes himſelf on firmer ground, and goes forward with greater ſecurity. Turning his attention to the preſent appearance of things upon this globe, he pronounces from the view that the whole earth was at firſt under water. This water he ſuppoſes to have been the lighter parts of its former evaporation, which, while the earthy particles ſunk downwards by their natural gravity, floated on the ſurface, and covered it for a conſiderable ſpace of time.

"The ſurface of the earth," ſays he*, "muſt have been in the beginning much leſs ſolid than it is at preſent; and, conſequently, the ſame cauſes, which at this day produce but very ſlight changes, muſt then, upon ſo complying a ſubſtance, have had very conſiderable effects. We have no reaſon to doubt but that it was then covered with the waters of the ſea; and that thoſe waters were above the tops of our higheſt mountains, ſince, even in ſuch elevated

* Theorie de la Terre, vol. 1, p. 111.

ſituations,

ſituations, we find ſhells and other marine productions in very great abundance. It appears alſo that the ſea continued for a conſiderable time upon the face of the earth: for as theſe layers of ſhells are found ſo very frequent at ſuch great depths, and in ſuch prodigious quantities, it ſeems impoſſible for theſe to have ſupported their numbers all alive at one time; ſo that they muſt have been brought there by ſucceſſive depoſitions. Theſe ſhells alſo are found in the bodies of the hardeſt rocks, where they could not have been depoſited, all at once, at the time of deluge, or at any ſuch inſtant revolution; ſince that would be to ſuppoſe, that all the rocks in which they are found, were, at that inſtant, in a ſtate of diſſolution, which would be abſurd to aſſert. The ſea, therefore, depoſited them whereſoever they are now to be found, and that by ſlow and ſucceſſive degrees.

It will appear, alſo, that the ſea covered the whole earth, from the appearance of its layers, which lying regularly one above the other, ſeem all to reſemble the ſediment formed at different times by the ocean. Hence, by the irregular force of its waves, and its currents driving the bottom into ſand-banks, mountains muſt have been gradually formed within this univerſal co-

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vering of waters; and theſe ſucceſſively raiſing their heads above its ſurface, muſt, in time, have formed the higheſt ridges of mountains upon land, together with continents, iſlands, and low grounds, all in their turns. This opinion will receive additional weight by conſidering, that in thoſe parts of the earth where the power of the ocean is greateſt, the inequalities on the ſurface of the earth are higheſt: the ocean's power is greateſt at the equator, where its winds and tides are moſt conſtant; and, in fact, the mountains at the equator are found to be higher than in any other part of the world. The ſea, therefore, has produced the principal changes in our earth: rivers, volcanoes, earthquakes, ſtorms, and rain, having made but ſlight alterations, and only ſuch as have affected the globe to very inconſiderable depths.

This is but a very ſlight ſketch of Mr. Buffon's Theory of the Earth; a theory which he has much more powerfully ſupported, than happily invented; and it would be needleſs to take up the reader's time from the purſuit of truth in the diſcuſſion of plauſibilities. In fact, a thouſand queſtions might be aſked this moſt ingenious philoſopher, which he would not find it eaſy to anſwer; but ſuch is the lot of humanity,

that

that a ſingle Goth can in one day deſtroy the fabric which Cæſars were employed an age in erecting. In fact, we might aſk, how mountains, which are compoſed of the moſt compact and ponderous ſubſtances, ſhould be the firſt whoſe parts the ſea began to remove? We might aſk, how foſſil-wood is found deeper even than ſhells? which argues, that trees grew upon the places he ſuppoſes once to have been covered with the ocean. But we hope this excellent man is better employed than to think of gratifying the petulance of incredulity, by anſwering endleſs objections.

CHAP. V.

Of Foſſil-ſhells, and other extraneous Foſſils.

WE may affirm of Mr. Buffon, that which has been ſaid of the chymiſts of old: though he may have failed in attaining his principal aim, of eſtabliſhing a theory, yet he has brought together ſuch a multitude of facts relative to the hiſtory of the earth, and the

the nature of its foſſil productions, that curioſity finds ample compenſation even while it feels the want of conviction.

Before, therefore, I enter upon the deſcription of thoſe parts of the earth, which ſeem more naturally to fall within the ſubject, it will not be improper to give a ſhort hiſtory of thoſe animal productions that are found in ſuch quantities, either upon its ſurface, or at different depths below it. They demand our curioſity, and, indeed, there is nothing in natural hiſtory that has afforded more ſcope for doubt, conjecture, and ſpeculation. Whatever depths of the earth we examine, or at whatever diſtance within land we ſeek, we moſt commonly find a number of foſſil-ſhells, which being compared with others from the ſea, of known kinds, are found to be exactly of a ſimilar ſhape and nature *. They are found at the very bottom of quarries and mines, in the moſt retired and inward parts of the moſt firm and ſolid rocks, upon the tops of even the higheſt hills and mountains, as well as in the valleys and plains: and this not in one country alone, but in all places where there is any digging for marble, chalk,

* Woodward's Eſſay towards a Natural Hiſtory, p. 16.

or

or any other terreſtrial matters, that are ſo compact as to fence off the external injuries of the air, and thus preſerve theſe ſhells from decay.

Theſe marine ſubſtances, ſo commonly diffuſed, and ſo generally to be met with, were for a long time conſidered by philoſophers, as productions, not of the ſea, but of the earth. "As we find that ſpars," ſaid they, "always ſhoot into peculiar ſhapes, ſo theſe ſeeming ſnails, cockles, and muſcle-ſhells, are only ſportive forms that nature aſſumes amongſt others of its mineral varieties: they have the ſhape of fiſh, indeed, but they have always been terreſtrial ſubſtances *."

With this plauſible ſolution mankind were for a long time content; but upon cloſer enquiry, they were obliged to alter their opinion. It was found that theſe ſhells had, in every reſpect, the properties of animal and not of mineral nature. They were found exactly of the ſame weight with their fellow ſhells upon ſhore. They anſwered all the chymical trials in the ſame manner as ſea ſhells do. Their parts, when diſſolved, had the ſame appearance to view, the ſame ſmell and taſte. They had the

* Lowth Abridgement. Phil. Tranſ. vol. ii. p. 426.

ſame

ſame effects in medicine when inwardly adminiſtered; and, in a word, were ſo exactly conformable to marine bodies, that they had all the accidental concretions growing to them, (ſuch as pearls, corals, and ſmaller ſhells) which are found in ſhells juſt gathered on the ſhore. They were, therefore, from theſe conſiderations, again given back to the ſea; but the wonder was, how to account for their coming ſo far from their own natural element upon land *.

As this naturally gave riſe to many conjectures, it is not to be wondered that ſome among them have been very extraordinary. An Italian, quoted by Mr. Buffon, ſuppoſes them to have been depoſited in the earth at the time of the cruſades, by the pilgrims who returned from Jeruſalem; who gathering them upon the ſea-ſhore, in their return carried them to their different places of habitation. But this conjecturer ſeems to have but a very inadequate idea of their numbers. At Touraine, in France, more than an hundred miles from the ſea, there is a plain of about nine leagues long, and as many broad, from whence the peaſants of the country ſupply themſelves with marle

* Woodward, p. 43.

for

for manuring their lands. They ſeldom dig deeper than twenty feet, and the whole plain is compoſed of the ſame materials, which are ſhells of various kinds, without the ſmalleſt portion of earth between them. Here, then, is a large ſpace, in which are depoſited millions of tons of ſhells, which pilgrims could not have collected though their whole employment had been nothing elſe. England is furniſhed with its beds, which though not quite ſo extenſive, yet are equally wonderful. * "Near Reading, in Berkſhire, for many ſucceeding generations, a continued body of oyſter-ſhells has been found through the whole circumference of five or ſix acres of ground. The foundation of theſe ſhells is an hard rocky chalk; and above this chalk, the oyſter-ſhells lie in a bed of green ſand, upon a level, as nigh as can poſſibly be judged, and about two feet thickneſs." Theſe ſhells are in their natural ſtate, but they are found alſo petrified, and almoſt in equal abundance † in all the Alpine rocks, in the Pyrenees, on the hills of France, England, and Flanders. Even in all quarries from

* Phil. Tranſ. vol. ii. p. 427.

† Buffon, vol. i. p. 407.

whence

whence marble is dug, if the rocks be ſplit perpendicularly downwards, petrified ſhells, and other marine ſubſtances, will be plainly diſcerned.

"About a quarter of a mile from the river Medway *, in the county of Kent, after the taking off the coping of a piece of ground there, the workmen came to a blue marble, which continued for three feet and an half deep, or more, and then beneath appeared an hard floor, or pavement, compoſed of petrified ſhells crowded cloſely together. This layer was about an inch deep, and ſeveral yards over; and it could be walked upon as upon a beach. Theſe ſtones, of which it was compoſed, (the deſcriber ſuppoſes them to have always been ſtones) were either wreathed as ſnails, or bivalvular like cockles. The wreathed kinds were about the ſize of an hazle-nut, and were filled with a ſtony ſubſtance of the colour of marle; and they themſelves, alſo, till they were waſhed, were of the ſame colour; but when cleaned, they appeared of the colour of bezoar, and of the ſame poliſh. After boiling in water they became whitiſh, and left a chalkineſs upon the fingers."

* Phil. Tranſ. p. 426.

In

In ſeveral parts of Aſia and Africa, travellers have obſerved theſe ſhells in great abundance. In the mountains of Caſtravan, which lie above the city Barut, they quarry out a white ſtone, every part of which contains petrified fiſhes in great numbers, and of ſurprizing diverſity. They alſo ſeem to continue in ſuch preſervation, that their fins, ſcales, and all the minuteſt diſtinctions of their make, can be perfectly diſcerned *.

From all theſe inſtances we may conclude, that theſe foſſils are very numerous; and, indeed, independent of their ſituation, they afford no ſmall entertainment to obſerve them as preſerved in the cabinets of the curious. The variety of their kinds is aſtoniſhing. Moſt of the ſea ſhells which are known, and many others to which we are entirely ſtrangers, are to be ſeen either in their natural ſtate, or in various degrees of petrefaction †. In the place of ſome we have mere ſpar, or ſtone, exactly expreſſing all the lineaments of animals, as having been wholly formed from them. For it has happened, that the ſhells diſſolving by very ſlow degrees, and the matter having nicely and exactly filled all the cavities within,

* Buffon, vol. i. p. 408. † Hill. p 646.

this

this matter, after the ſhells have periſhed, has preſerved exactly and regularly the whole print of their internal ſurface. Of theſe there are various kinds found in our pits; many of them reſembling thoſe of our own ſhores; and many others that are only to be found on the coaſts of other countries. There are ſome ſhells reſembling thoſe that are never ſtranded upon our coaſts *, but that always remain in the deep †: and many more there are which we can aſſimilate with no ſhells that are known amongſt us. But we find not only ſhells in our pits, but alſo fiſhes and corals in great abundance; together with almoſt every ſort of marine production.

It is extraordinary enough, however, that the common red coral, though ſo very frequent at ſea, is ſcarce ſeen in the foſſil world; nor is there any account of its having ever been met with. But to recompenſe for this, there are all the kinds of the white coral now known; and many other kinds of that ſubſtance with which we are unacquainted. Of animals there are various parts; the vertebræ of whales, and the mouths of leſſer fiſhes; theſe, with teeth

* Littorales. † Pelagii.

alſo

alſo of various kinds, are found in the cabinets of the curious; where they receive long Greek names, which it is neither the intention nor the province of this work to enumerate. Indeed, few readers would think themſelves much improved, ſhould I proceed with enumerating the various claſſes of the Conicthyodontes, Polyleptoginglimi, or the Orthoceratites. Theſe names, which mean no great matter when they are explained, may ſerve to guide in the furniſhing a cabinet; but they are of very little ſervice in furniſhing the page of inſtructive hiſtory.

From all theſe inſtances we ſee in what abundance theſe petrefactions are to be found; and, indeed, Mr. Buffon, to whoſe accounts we have added ſome, has not been ſparing in the variety of his quotations, concerning the places where they are moſtly to be found. However, I am ſurprized that he ſhould have omitted the mention of one, which, in ſome meaſure, more than any of the reſt, would have ſerved to ſtrengthen his theory. We are informed, by almoſt every traveller *, that has deſcribed the pyramids of Egypt, that one of them is entirely built of a kind of free-ſtone, in

* Haſſelquiſt, Sandys.

which

which theſe petrified ſhells are found in great abundance. This being the caſe, it may be conjectured, as we have accounts of theſe pyramids among the earlieſt records of mankind, and of their being built ſo long before the age of Herodotus, who lived but fifteen hundred years after the flood, that even the Egyptian prieſts could tell neither the time nor the cauſe of their erection; I ſay it may be conjectured that they were erected but a ſhort time after the flood. It is not very likely, therefore, that the marine ſubſtances found in one of them, had time to be formed into a part of the ſolid ſtone, either during the deluge, or immediately after it; and, conſequently, their petrefaction muſt have been before that period. And this is the opinion Mr. Buffon has all along ſo ſtrenuouſly endeavoured to maintain; having given ſpecious reaſons to prove, that ſuch ſhells were laid in the beds where they are now found, not only before the deluge, but even antecedent to the formation of man, at the time when the whole earth, as he ſuppoſes, was buried beneath a covering of waters.

But while there are many reaſons to perſuade us that theſe extraneous foſſils have been depoſited by the ſea, there is one fact that

that will abundantly ſerve to convince us that the earth was habitable, if not inhabited, before theſe marine ſubſtances came to be thus depoſited. For we find foſſil trees, which no doubt once grew upon the earth, as deep, and as much in the body of ſolid rocks, as theſe ſhells are found to be. Some of theſe fallen trees alſo, have lain at leaſt as long, if not longer, in the earth, than the ſhells, as they have been found ſunk deep in a marly ſubſtance, compoſed of decayed ſhells, and other marine productions. Mr. Buffon has proved that foſſil ſhells could not have been depoſited in ſuch quantities all at once by the flood; and I think, from the above inſtance, it is pretty plain, that, howſoever they were depoſited, the earth was covered with trees before their depoſition; and, conſequently, that the ſea could not have made a very permanent ſtay. How then ſhall we account for theſe extraordinary appearances in nature? A ſuſpenſion of all aſſent is certainly the firſt, although the moſt mortifying conduct. For my own part, were I to offer a conjecture, and all that has been ſaid upon this ſubject is but conjecture, inſtead of ſuppoſing them to be the remains of animals belonging to the ſea, I would conſider them rather as bred in the numerous freſh-water lakes,

that, in primæval times, covered the face of uncultivated nature. Some of theſe ſhells we know to belong to freſh waters: ſome can be aſſimilated to none of the marine ſhells now known *; why, therefore, may we not as well aſcribe the production of all to freſh waters, where we do not find them, as we do that of the latter to the ſea only, where we never find them? We know that lakes, and lands alſo, have produced animals that are now no longer exiſting, why, therefore, might not theſe foſſil productions be among the number? I grant that this is making a very harſh ſuppoſition; but I cannot avoid thinking, that it is not attended with ſo many embarraſſments as ſome of the former, and that it is much eaſier to believe that theſe ſhells were bred in freſh water, than that the ſea had for a long time covered the tops of the higheſt mountains.

* Hill's Foſſils, p. 641.

CHAP. VII.

Of the internal Structure of the Earth.

HAVING, in ſome meaſure, got free from the regions of conjecture, let us now proceed to a deſcription of the earth as we find it by examination, and obſerve its internal compoſition, as far as it has been the ſubject of experience, or expoſed to human enquiry. Theſe enquiries, indeed, have been carried but to a very little depth below its ſurface, and even in that diſquiſition men have been conducted more by motives of avarice than of curioſity. The deepeſt mine, which is that at Cotteberg in Hungary *, reaches not more than three thouſand feet deep; but what proportion does that bear to the depth of the terreſtrial globe, down to the centre, which is above four thouſand miles? All, therefore, that has been ſaid of the earth, to a deeper degree, is merely fabulous or conjectural: we may ſuppoſe with one, that it is a globe of glaſs †; with another, a ſphere of heated iron ‡; with a third, a great maſs of

* Boyle, vol. iii. p. 240. † Buffon. ‡ Whiſton.

waters *; and with a fourth, one dreadful volcano †; but let us, at the ſame time, ſhew our conſciouſneſs, that all theſe are but ſuppoſitions.

Upon examining the earth, where it has been opened to any depth, the firſt thing that occurs, is the different layers or beds of which it is compoſed: theſe all lying horizontally one over the other like the leaves of a book, and each of them compoſed of materials that encreaſe in weight in proportion as they lie deeper. This is, in general, the diſpoſition of the different materials where the earth ſeems to have remained unmoleſted; but this order is frequently inverted; and we cannot tell whether from its original formation, or from accidental cauſes. Of different ſubſtances, thus diſpoſed, the far greateſt part of our globe conſiſts, from its ſurface downwards to the greateſt depths we ever dig or mine ‡.

The firſt layer that is moſt commonly found at the ſurface, is that light coat of blackiſh mold, which is called, by ſome, garden earth. With this the earth is every where inveſted, unleſs it be waſhed off by rains, or removed by ſome other external violence. This ſeems to have been formed

* Burnet. † Kircher. ‡ Woodward, p. 9.

from

from animal and vegetable bodies decaying, and thus turning into its ſubſtance. It alſo ſerves again as a ſtore-houſe, from whence animal and vegetable nature are renewed, and thus are all vital bleſſings continued with unceaſing circulation. This earth, however, is not to be ſuppoſed entirely pure, but is mixed up with much ſtony and gravelly matter from the layers lying immediately beneath it. It generally happens, that the ſoil is fertile in proportion to the quantity that this putrified mold bears to the gravelly mixture; and as the former predominates, ſo far is the vegetation upon it more luxuriant. It is this external covering that ſupplies man with all the true riches he enjoys. He may bring up gold and jewels from greater depths; but they are merely the toys of a capricious being, things upon which he has placed an imaginary value, and for which fools alone part with the more ſubſtantial bleſſings of life. It is this earth, ſays Pliny †, that, like a kind mother, receives us at our birth, and ſuſtains us when born. It is this alone, of all the elements around us, that is never found an enemy to man. The body of waters deluge him with rains, oppreſs him with hail, and drown him with inundations. The air ruſhes in ſtorms, prepares

† Plinii Naturalis Hiſtoria, lib. 2. cap. 63.

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the tempeſt, or lights up the volcano; but the earth, gentle and indulgent, ever ſubſervient to the wants of man, ſpreads his walks with flowers, and his table with plenty; returns with intereſt every good committed to her care; and, though ſhe produces the poiſon, ſhe ſtill ſupplies the antidote; though conſtantly teized more to furniſh the luxuries of man than his neceſſities, yet, even to the laſt, ſhe continues her kind indulgence, and, when life is over, ſhe piouſly covers his remains in her boſom.

This external and fruitful layer which covers the earth, is, as was ſaid, in a ſtate of continual change. Vegetables, which are naturally fixed and rooted to the ſame place, receive their adventitious nouriſhment from the ſurrounding earth and water: animals, which change from place to place, are ſupported by theſe, or by each other. Both, however, having for a time enjoyed a life adapted to their nature, give back to the earth thoſe ſpoils, which they had borrowed for a very ſhort ſpace, yet ſtill to be quickened again into freſh exiſtence. But the depoſits they make are of very diſſimilar kinds, and the earth is very differently enriched by their continuance. Thoſe countries that have for a long time ſupported men and other animals, having been obſerved to become every day more barren,

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while, on the contrary, thoſe deſolate places, in which vegetables only are abundantly produced, are known to be poſſeſt of amazing fertility. * "In regions which are uninhabited," ſays Mr. Buffon, "where the foreſts are not cut down, and where animals do not feed upon the plants, the bed of vegetable earth is conſtantly encreaſing. In all woods, and even in thoſe which are often cut, there is a layer of earth of ſix or eight inches thick, which has been formed by the leaves, branches and bark, which fall and rot upon the ground. I have frequently obſerved on a Roman way that croſſes Burgundy for a long extent, that there is a bed of black earth, of more than a foot thick, gathered over the ſtony pavement, on which ſeveral trees, of a very conſiderable ſize, are ſupported. This I have found to be nothing elſe than an earth formed by decayed leaves and branches, which have been converted by time into a black ſoil. Now as vegetables draw much more of their nouriſhment from the air and water than they do from the earth, it muſt follow, that in rotting upon the ground, they muſt give more to the ſoil than they have taken from it. Hence, therefore, in woods kept a long time without cutting, the ſoil below encreaſes to a

* Buffon, vol. i. 353.

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conſiderable depth; and ſuch we actually find the ſoil in thoſe American wilds where the foreſts have been undiſturbed for ages. But it is otherwiſe where men and animals have long ſubſiſted; for as they make a conſiderable conſumption of wood and plants, both for firing and other uſes, they take more from the earth than they return to it: it follows, therefore, that the bed of vegetable earth, in an inhabited country, muſt be always diminiſhing; and muſt, at length, reſemble the ſoil of Arabia Petrea, and other provinces of the Eaſt, which having been long inhabited, are now become plains of ſalt and ſand; the fixed ſalt always remaining, while the other volatile parts have flown away."

If from this external ſurface we deſcend deeper, and view the earth cut perpendicularly downwards, either in the banks of great rivers, or ſteepy ſea ſhores; or, going ſtill deeper, if we obſerve it in quarries or mines, we ſhall find its layers regularly diſpoſed in their proper order. We muſt not expect, however, to find them of the ſame kind or thickneſs in every place, as they differ in different ſoils and ſituations. Sometimes marle is ſeen to be over ſand, and ſometimes under it. The moſt common diſpoſition is, that under the firſt earth

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is found gravel or ſand, then clay or marle, then chalk or coal, marbles, ores, ſands, gravels, and thus an alternation of theſe ſubſtances, each growing more denſe as it ſinks deeper. The clay, for inſtance, found at the depth of an hundred feet, is uſually more heavy than that found not far from the ſurface. In a well which was dug at Amſterdam, to the depth of two hundred and thirty feet, the following ſubſtances were found in ſucceſſion*: ſeven feet of vegetable earth, nine of turf, nine of ſoft clay, eight of ſand, four of earth, ten of clay, four of earth, ten of ſand, two of clay, four of white ſand, one of ſoft earth, fourteen of ſand, eight of clay mixed with ſand, four of ſea-ſand mixed with ſhells, then an hundred and two feet of ſoft clay, and then thirty-one feet of ſand.

In a well dug at Marly, to the depth of an hundred feet, Mr. Buffon gives us a ſtill more exact enumeration of its layers of earth. Thirteen of a reddiſh gravel, two of gravel mingled with a vitrifiable ſand, three of limon, two of marle, four of marly ſtone, five of marle in duſt mixed with vitrifiable ſand, ſix of very fine vitrifiable ſand, three of earthy marle, three of hard marle,

* Varenius, as quoted by Mr. Buffon, p. 358.

one

one of gravel, one of eglantine, a ſtone of the hardneſs and grain of marble, one of gravelly marle, one of ſtony marle, one of a coarſer kind of ſtony marle, two of a coarſer kind ſtill, one of vitrifiable ſand mixed with foſſil ſhells, two of fine gravel, three of ſtony marle, one of coarſe powdered marle, one of ſtone, calcinable like marble, three of grey ſand, two of white ſand, one of red ſand ſtreaked with white, eight of grey ſand with ſhells, three of very fine ſand, three of gres, four of red ſand ſtreaked with white, three of white ſand, and fifteen of reddiſh vitrifiable ſand."

In this manner the earth is every where found in beds over beds; and, what is ſtill remarkable, each of them, as far as it extends, always maintains exactly the ſame thickneſs. It is found alſo, that, as we proceed to conſiderable depths, every layer grows thicker. Thus in the adduced inſtances we might have obſerved, that the laſt layer was fifteen feet thick, while moſt of the others were not above eight, and this might have gone much deeper, for aught we can tell, as before they got through it the workmen ceaſed digging.

Theſe layers are ſometimes very extenſive, and often are found to obtain over a ſpace of ſome leagues in circumference. But

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it muſt not be ſuppoſed that they are uniformly continued over the whole globe without any interruption: on the contrary, they are ever, at ſmall intervals, cracked through as it were by perpendicular fiſſures; the earth reſembling, in this reſpect, the muddy bottom of a pond, from whence the water has been dried off by the ſun, and thus gaping in ſeveral chinks, which deſcend in a direction perpendicular to its ſurface. Theſe fiſſures are many times found empty, but oftener cloſed up with adventitious ſubſtances, that the rain, or ſome other accidental cauſes, have conveyed to fill their cavities. Their openings are not leſs different than their contents, ſome being not above half an inch wide, ſome a foot, and ſome ſeveral hundred yards aſunder. Theſe laſt form thoſe dreadful chaſms that are to be found in the Alps, at the edge of which the traveller ſtands dreading to look down at the immeaſurable gulph below. Theſe amazing clefts are well known to ſuch as have paſt theſe mountains, where a chaſm frequently preſents itſelf ſeveral hundred feet deep, and as many over, at the edge of which the way lies. It often happens alſo, that the road leads along the bottom, and then the ſpectator obſerves on each ſide frightful precipices ſeveral hundred yards above

above him; the ſides of which tally ſo exactly with each other, that they evidently ſeem torn aſunder.

But theſe chaſms to be found in the Alps, are nothing to what Ovalle tells us are to be ſeen in the Andes. Theſe amazing mountains, in compariſon of which the former are but little hills, have their fiſſures in proportion to their greatneſs. In ſome places they are a mile wide, and deep in proportion; and there are ſome others, that running underground, in extent reſemble a province.

Of this kind alſo is that cavern called Elden-hole, in Derbyſhire; which, Dr. Plot tells us, was ſounded by a line of eight and twenty hundred feet, without finding the bottom, or meeting with water: and yet the mouth at the top is not above forty yards over*. This immeaſurable cavern runs perpendicularly downward; and the ſides of it ſeem to tally ſo plainly as to ſhew that they once were united. Thoſe who come to viſit the place, generally procure ſtone to be thrown into its mouth; and theſe are heard for ſeveral minutes, falling and ſtriking againſt the ſides of the cavern, producing a ſound that reſembles diſtant thunder, dying away as the ſtone goes deeper.

* Phil. Tranſ. vol. ii. p. 370.

Of

Of this kind alſo is that dreadful cavern deſcribed by Ælian; his account of which the reader may not have met with ‡. "In the country of the Arrian Indians, is to be ſeen an amazing chaſm, which is called, the Gulph of Pluto. The depth, and the receſſes of this horrid place, are as extenſive as they are unknown. Neither the natives, nor the curious who viſit it, are able to tell how it firſt was made, or to what depths it deſcends. The Indians continually drive thither great multitudes of animals, more than three thouſand at a time, of different kinds, ſheep, horſes and goats; and, with an abſurd ſuperſtition, force them into the cavity, from whence they never return. Their ſeveral ſounds, however, are heard as they deſcend; the bleating of ſheep, the lowing of oxen, and the neighing of horſes, iſſuing up to the mouth of the cavern. Nor do theſe ſounds ceaſe, as the place is continually furniſhed with a freſh ſupply."

There are many more of theſe dreadful perpendicular fiſſures in different parts of the earth; with accounts of which, Kircher, Gaffarellus, and others who have given hiſtories of the wonders of the ſubterranean world, abundantly ſupply us. The generality of readers, however, will conſider them with leſs aſtoniſhment, when they are informed of their being common all over the earth: that in

‡ Æliani Var. Hiſt. lib. 16, cap. 16.

every

every field, in every quarry, theſe perpendicular fiſſures are to be found; either ſtill gaping, or filled with matter that has accidentally cloſed their interſtices. The inattentive ſpectator neglects the enquiry, but their being common is partly the cauſe that excites the philoſopher's attention to them; the irregularities of nature he is often content to let paſs unexamined; but when a conſtant and a common appearance preſents itſelf, every return of the object is a freſh call to his curioſity; and the chink in the next quarry becomes as great a matter of wonder as the chaſm in Elden-hole. Philoſophers have long, therefore, endeavoured to find out the cauſe of theſe perpendicular fiſſures, which our own countrymen, Woodward and Ray, were the firſt that found to be ſo common and univerſal. Mr. Buffon ſuppoſes them to be cracks made by the ſun, in drying up the earth immediately after its emerſion from the deep. The heat of the ſun is very probably a principal cauſe; but it is not right to aſcribe to one only, what we find may be the reſult of many. Earthquakes, ſevere froſts, burſting waters, and ſtorms tearing up the roots of trees, have, in our times, produced them: and to this variety of cauſes, we muſt, at preſent, be content to aſſign thoſe that have happened before we had opportunities for obſervation.

CHAP.

CHAP. VIII.

Of Caves and ſubterraneous Paſſages that ſink, but not perpendicularly, into the Earth.

IN ſurveying the ſubterranean wonders of the globe, beſides thoſe fiſſures that deſcend perpendicularly downwards, we frequently find others that deſcend but a little way, and then ſpread themſelves often to a great extent below the ſurface. Many of theſe caverns, it muſt be confeſſed, may be the production of art and human induſtry; retreats made to protect the oppreſſed, or ſhelter the ſpoiler. The famous labyrinth of Candia, for inſtance, is ſuppoſed to be entirely the work of art. Mr. Tournefort aſſures us, that it bears the impreſſion of human induſtry, and that great pains have been beſtowed upon its formation. The ſtone-quarry of Maeſtricht is evidently made by labour: carts enter at its mouth, and load within, then return and diſcharge their freight into boats that lie on the brink of the river Maeſe. This quarry is ſo large, that forty thouſand people may take ſhelter in it: and it in general ſerves for this purpoſe, when armies march that way; becoming then an impregnable retreat to the people

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that live thereabout. Nothing can be more beautiful than this cavern, when lighted up with torches; for there are thouſands of ſquare pillars, in large level walks, about twenty feet high; and all wrought with much neatneſs and regularity. In this vaſt grotto there is very little rubbiſh; which ſhews both the goodneſs of the ſtone, and the carefulneſs of the workmen. To add to its beauty, there alſo are in various parts of it, little pools of water, for the convenience of the men and cattle. It is remarkable alſo, that no droppings are ſeen to fall from the roof, nor are the walks any way wet under foot, except in caſes of great rains, where the water gets in by the air-ſhafts. The Salt mines in Poland are ſtill more ſpacious than theſe. Some of the catacombs, both in Egypt and Italy, are ſaid to be very extenſive. But no part of the world has a greater number of artificial caverns than Spain, which were made to ſerve as retreats to the Chriſtians, againſt the fury of the Moors, when the latter conquered that country. However, an account of the works of art, does not properly belong to a natural hiſtory. It will be enough to obſerve, that though caverns be found in every country, far the greateſt part of them have been faſhioned only by the hand of Nature. Their ſize is found beyond the

power

power of man to have effected; and their forms but ill adapted to the conveniences of an human habitation. In ſome places, indeed, we find mankind ſtill make uſe of them as houſes; particularly in thoſe countries where the climate is very ſevere *; but in general they are deſerted by every race of meaner animals, except the bat; theſe nocturnal ſolitary creatures are uſually the only inhabitants; and theſe only in ſuch whoſe deſcent is ſloping, or, at leaſt, not directly perpendicular.

There is ſcarce a country in the world without its natural caverns; and many new ones are diſcovered every day. Of thoſe in England, Wokey-hole, The Devil's-hole, and Penpark-hole, have been often deſcribed. The former, which lies on the ſouth ſide of Mendip-hills †, within a mile of the town of Wells, is much reſorted to by travellers. To conceive a juſt idea of this, we muſt imagine a precipice of more than an hundred yards high, on the ſide of a mountain which ſhelves away a mile above it. In this is an opening not very large, into which you enter, going along upon a rocky uneven pavement, ſometimes aſcending, and ſometimes deſcending. The roof of it, as you advance, grows higher; and, in ſome places, is fifty feet from

* Phil. Tranſ. vol. ii. p. 368. † Ibid.

the floor. In ſome places, however, it is ſo low that a man muſt ſtoop to paſs. It extends itſelf, in length, about two hundred yards; and from every part of the roof, and the floor, there are formed ſparry concretions of various figures, that by ſtrong imaginations have been likened to men, lions, and organs. At the fartheſt part of this cavern riſes a ſtream of water, well ſtored with fiſh, large enough to turn a mill, and which diſcharges itſelf near the entrance.

Penpark-hole, in Glouceſterſhire, is almoſt as remarkable as the former. Captain Sturmey deſcended into this by a rope, twenty-five fathoms perpendicular, and at the bottom found a very large vault in the ſhape of an horſe-ſhoe. The floors conſiſted of a kind of white ſtone enamelled with lead ore, and the pendent rocks were glazed with ſpar. Walking forward on this ſtony pavement, for ſome time, he came to a great river, twenty fathoms broad, and eight fathoms deep; and having been informed that it ebbed and flowed with the ſea, he remained in this gloomy abode for five hours, to make an exact obſervation. He did not find, however, any alteration whatſoever in its appearance. But his curioſity was ill requited; for it coſt this unfortunate gentleman his life: immediately after

after his return, he was ſeized with an unuſual and violent head-ach, which threw him into a fever, of which he died ſoon after.

But of all the ſubterraneous caverns now known, the grotto of Antiparos is the moſt remarkable, as well for its extent, as for the beauty of its ſparry incruſtations. This celebrated cavern was firſt diſcovered by one Magni, an Italian traveller, about an hundred years ago, at Antiparos, an inconſiderable iſland of the Archipelago *. The account he gives of it is long and inflated, but upon the whole amuſing. "Having been informed," ſays he, "by the natives of Paros, that in the little iſland of Antiparos, which lies about two miles from the former, of a gigantic ſtatue that was to be ſeen at the mouth of a cavern in that place, it was reſolved that we (the French conſul and himſelf) ſhould pay it a viſit. In purſuance of this reſolution, after we had landed on the iſland, and walked about four miles thro' the midſt of beautiful plains, and ſloping woodlands, we at length came to a little hill, on the ſide of which yawned a moſt horrid cavern, that with its gloom at firſt ſtruck us with terror, and almoſt repreſt curioſity. Recovering the firſt ſur-

* Kircher Mund. ſub. 122. I have tranſlated a part of Kircher's deſcription, rather than Tournefort's, as the latter was written to ſupport an hypotheſis.

prize, however, we entered boldly; and had not proceeded above twenty paces, when the ſuppoſed ſtatue of the giant preſented itſelf to our view. We quickly perceived, that what the ignorant natives had been terrified at as a giant, was nothing more than a ſparry concretion, formed by the water dropping from the roof of the cave, and by degrees hardening into a figure that their fears had formed into a monſter. Incited by this extraordinary appearance, we were induced to proceed ſtill farther, in queſt of new adventures in this ſubterranean abode. As we proceeded, new wonders offered themſelves; the ſpars, formed into trees and ſhrubs, preſented a kind of petrified grove; ſome white, ſome green; and all receding in due perſpective. They ſtruck us with the more amazement, as we knew them to be mere productions of Nature, who, hitherto in ſolitude, had, in her playful moments, dreſſed the ſcene, as if for her own amuſement.

"But we had as yet ſeen but a few of the wonders of the place; and we were introduced as yet only into the portico of this amazing temple. In one corner of this half illuminated receſs, there appeared an opening of about three feet wide, which ſeemed to lead to a place totally dark, and that one of the

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natives aſſured us contained nothing more than a reſervoir of water. Upon this we tried, by throwing down ſome ſtones, which rumbling along the ſides of the deſcent for ſome time, the ſound ſeemed at laſt quaſhed in a bed of water. In order, however, to be more certain, we ſent in a Levantine mariner, who, by the promiſe of a good reward, with a flambeau in his hand, ventured into this narrow aperture. After continuing within it for about a quarter of an hour, he returned, carrying ſome beautiful pieces of white ſpar in his hand, which art could neither imitate nor equal. Upon being informed by him that the place was full of theſe beautiful incruſtations, I ventured in once more with him, for about fifty paces, anxiouſly and cautiouſly deſcending by a ſteep and dangerous way. Finding, however, that we came to a precipice which led into a ſpacious amphitheatre, if I may ſo call it, ſtill deeper than any other part, we returned, and being provided with a ladder, flambeaux, and other things to expedite our deſcent, our whole company, man by man, ventured into the ſame opening, and deſcending one after another, we at laſt ſaw ourſelves all together in the moſt magnificent part of the cavern.

" Our candles being now all lighted up, and the whole place completely illuminated, never could the eye be preſented with a more glittering, or a more magnificent ſcene. The roof all hung with ſolid iſicles, tranſparent as glaſs, yet ſolid as marble. The eye could ſcarce reach the lofty and noble cieling; the ſides were regularly formed with ſpars; and the whole preſented the idea of a magnificent theatre, illuminated with an immenſe profuſion of lights. The floor conſiſted of ſolid marble; and in ſeveral places, magnificent columns, thrones, altars, and other objects appeared, as if nature had deſigned to mock the curioſities of art. Our voices, upon ſpeaking or ſinging, were redoubled to an aſtoniſhing loudneſs; and upon the firing of a gun, the noiſe and reverberations were almoſt deafening. In the midſt of this grand amphitheatre roſe a concretion of about fifteen feet high, that, in ſome meaſure, reſembled an altar; from which, taking the hint, we cauſed maſs to be celebrated there. The beautiful columns that ſhot up round the altar, appeared like candleſticks; and many other natural objects repreſented the cuſtomary ornaments of this ſacrament.

" Below even this ſpacious grotto, there ſeemed another cavern; down which I ventured with my former mariner, and deſcend-

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ed about fifty paces by means of a rope. I at laſt arrived at a ſmall ſpot of level ground, where the bottom appeared different from that of the amphitheatre, being compoſed of ſoft clay, yielding to the preſſure, and in which I thruſt a ſtick to about ſix feet deep. In this, however, as above, numbers of the moſt beautiful chryſtals were formed; one of which, particularly reſembled a table. Upon our egreſs from this amazing cavern, we perceived a Greek inſcription upon a rock at the mouth, but ſo obliterated by time, that we could not read it. It ſeemed to import that one Antipater, in the time of Alexander, had come thither; but whether he penetrated into the depths of the cavern, he does not think fit to inform us."

Such is the account of this beautiful ſcene, as communicated in a letter to Kircher. We have another, and a more copious deſcription of it by Tournefort, which is in every body's hands; but I have given the above, both becauſe it was communicated by the firſt diſcoverer, and becauſe it is a ſimple narrative of facts, without any reaſoning upon them. According to Tournefort's account, indeed, we might conclude, from the rapid growth of the ſpars in this grotto, that it muſt every year be growing narrower, and that it muſt,

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in time, be choaked up with them entirely; but no ſuch thing has happened hitherto, and the grotto at this day continues as ſpacious as we ever knew it.

This is not the place for an enquiry into the ſeeming vegetation of thoſe ſtony ſubſtances with which this and almoſt every cavern are incruſted. It is enough to obſerve, in general, that they are formed by an accumulation of that little gritty matter which is carried thither by the waters, and which in time acquires the hardneſs of marble. What in this place more imports us to know is, how theſe amazing hollows in the earth came to be formed. And I think, in the three inſtances above-mentioned, it is pretty evident, that their excavation has been owing to waters. Theſe finding ſubterraneous paſſages under the earth, and by long degrees hollowing the beds in which they flowed, the ground above them has ſlipt down cloſer to their ſurface, leaving the upper layers of the earth or ſtone ſtill ſuſpended. The ground that ſinks upon the face of the waters forming the floor of the cavern; the ground, or rock that keeps ſuſpended, forming the roof: and, indeed, there are but few of theſe caverns found without water, either within them, or near enough to point out their formation.

CHAP. VIII.

Of Mines, Damps, and Mineral Vapours.

THE caverns, which we have been deſcribing, generally carry us but a very little way below the ſurface of the earth. Two hundred feet, at the utmoſt, is as much as the loweſt of them is found to ſink. The perpendicular fiſſures run much deeper; but few perſons have been bold enough to venture down to their deepeſt receſſes: and ſome few who have tried, have been able to bring back no tidings of the place, for unfortunately they left their lives below. The excavations of art have conducted us much further into the bowels of the globe. Some mines in Hungary are known to be a thouſand yards perpendicularly downwards; and I have been informed, by good authority, of a coal mine in the north of England, an hundred yards deeper ſtill.

It is beſide our preſent purpoſe to enquire into the peculiar conſtruction and contrivance of theſe, which more properly belongs to the hiſtory of foſſils. It will be ſufficient to obſerve in this place, that as we deſcend into

into the mines, the various layers of earth are ſeen, as we have already deſcribed them; and in ſome of theſe are always found the metals or minerals, for which the mine has been dug. Thus frequently gold is found diſperſed and mixed with clay and gravel*; ſometimes it is mingled with other metallic bodies, ſtones, or bitumens; and † ſometimes united with that moſt obſtinate of all ſubſtances, platina, from which ſcarce any art can ſeparate it. Silver is ſometimes found quite pure‡, ſometimes mixed with other ſubſtances and minerals. Copper is found in beds mixed with various ſubſtances, marbles, ſulphurs, and pyrites. Tin, the ore of which is heavier than that of any other metal, is generally found mixed with every kind of matter: § lead is alſo equally common; and iron we well know can be extracted from all the ſubſtances upon earth.

The variety of ſubſtances which are thus found in the bowels of the earth, in their native ſtate, have a very different appearance from what they are afterwards taught to aſſume by human induſtry. The richeſt metals are very often leſs glittering and ſplendid

* Ulloa, vol. ii. p. 470. † Ulloa, ibid.
‡ Macquer's Chymiſtry, vol. i. p. 316.
§ Hill's Foſſils, p. 628.

than

than the moſt uſeleſs marcaſites, and the baſeſt ores are in general the moſt beautiful to the eye.

This variety of ſubſtances, which compoſe the internal parts of our globe, is productive of equal varieties, both above and below its ſurface. The combination of the different minerals with each other, the heats which ariſe from their mixture, the vapours they diffuſe, the fires which they generate, or the colds which they ſometimes produce, are all either noxious or ſalutary to man; ſo that in this elaboratory of nature, a thouſand benefits and calamities are forging, of which we are wholly unconſcious; and it is happy for us that we are ſo.

* Upon our deſcent into mines of conſiderable depth, the cold ſeems to encreaſe from the mouth as we deſcend; but after paſſing very low down, we begin, by degrees, to come into a warmer air, which ſenſibly grows hotter as we go deeper, till, at laſt, the labourers can ſcarce bear any covering as they continue working.

This difference in the air was ſuppoſed by Boyle to proceed from magazines of fire that lay nearer the centre, and that diffuſed their heat to the adjacent regions. But we now

* Boyle, vol. iii. p. 232.

know

know that it may be aſcribed to more obvious cauſes. In ſome mines, the compoſition of the earth all around is of ſuch a nature, that upon the admiſſion of water or air, it frequently becomes hot, and often burſts out into eruptions. Beſide this, as the external air cannot readily reach the bottom, or be renewed there, an obſervable heat is perceived below, without the neceſſity of recurring to the central heat for an explanation.

Hence, therefore, there are two principal cauſes of the warmth at the bottom of mines: the heat of the ſubſtances of which the ſides are compoſed; and the want of renovation in the air below. Any ſulphureous ſubſtance mixed with iron, produces a very great heat, by the admiſſion of water. If, for inſtance, a quantity of ſulphur be mixed with a proportionable ſhare of iron filings, and both kneaded together into a ſoft paſte, with water, they will ſoon grow hot, and at laſt produce a flame. This experiment, produced by art, is very commonly effected within the bowels of the earth by nature. Sulphurs and irons are intimately blended together, and want only the mixture of water or air to excite their heat; and this, when once raiſed, is communicated to all bodies that lie within the ſphere of their operation. Thoſe beautiful

minerals,

minerals, called marcaſites and pyrites, are often of this compoſition; and wherever they are found, either by imbibing the moiſture of the air, or having been by any means combined with water, they render the mine conſiderably hot *.

The want of freſh air, alſo, at theſe depths, is, as we have ſaid, another reaſon for their being found much hotter. Indeed, without the aſſiſtance of art, the bottom of moſt mines would, from this cauſe, be inſupportable. To remedy this inconvenience, the miners are often obliged to ſink, at ſome convenient diſtance from the mouth of the pit where they are at work, another pit, which joins the former below, and which, in Derbyſhire, is called an air-ſhaft. Through this the air circulates; and thus the workmen are enabled to breathe freely at the bottom of the place; which becomes, as Mr. Boyle affirms, very commodious for reſpiration; and alſo very temperate as to heat and cold †. Mr. Locke, however, who has left us an account of the Mendip mines, ſeems to preſent a different picture. "The deſcent into theſe is exceeding difficult and dangerous; for they are not ſunk like wells,

* Kircher Mund. Subt. vol. ii. p. 216.

† Boyle, vol. iii. p. 238.

perpen-

perpendicularly, but as the crannies of the rocks happen to run. The conſtant method is to ſwing down by a rope, placed under the arms, and clamber along, by applying both feet and hands to the ſides of the narrow paſſage. The air is conveyed into them through a little paſſage that runs along the ſides from the top, where they ſet up ſome turfs, on the lee-ſide of the hole, to catch and force it down. Theſe turfs being removed to the windy ſide, or laid over the mouth of the hole, the miners below preſently want breath, and faint; and if ſweet ſwelling flowers chance to be placed there, they immediately loſe their fragrancy, and ſtink like carrion. An air ſo very putrifying can never be very commodious for reſpiration.

Indeed, if we examine the complexion of moſt miners, we ſhall be very well able to form a judgment of the unwholſomneſs of the place where they are confined. Their pale and ſallow looks ſhew how much the air is damaged by paſſing through thoſe deep and winding ways, that are rendered humid by damps, or warmed with noxious exhalations. But although every mine is unwholſome, all are not equally ſo. Coal-mines are generally leſs noxious than thoſe of tin; tin than thoſe of copper; but of all, none are ſo dreadfully deſtructive as thoſe of quickſilver.

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At the mines near the village of Idra, nothing can adequately deſcribe the deplorable infirmities of ſuch as fill the hoſpital there: emaciated and crippled, every limb contracted or convulſed, and ſome in a manner tranſpiring quickſilver at every pore. There was one man, ſays Dr. Pope *, who was not in the mines above half a year, and yet whoſe body was ſo impregnated with this mineral, that putting a piece of braſs money in his mouth, or rubbing it between his fingers, it immediately became as white as if it had been waſhed over with quickſilver. In this manner all the workmen are killed, ſooner or later; firſt becoming paralytic, and then dying conſumptive: and all this they ſuſtain for the trifling reward of ſevenpence a day.

But theſe metallic mines are not ſo noxious from their own vapours, as from thoſe of the ſubſtances with which the ores are uſually united, ſuch as arſenic, cinnabar, bitumen, or vitriol. From the fumes of theſe, variouſly combined, and kept encloſed, are produced thoſe various damps that put on ſo many dreadful forms, and are uſually ſo fatal. Sometimes thoſe noxious vapours are perceived by the delightful fragrance of their ſmell †, ſomewhat reſembling the pea-bloſ-

* Phil. Tranſ. vol. ii. p. 578. † Ibid. p. 375.

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ſom in bloom, from whence one kind of damp has its name. The miners are not deceived, however, by its flattering appearances; but as they thus have timely notice of its coming, they avoid it while it continues, which is generally during the whole ſummer ſeaſon. Another ſhews its approach by the burning of the candles, which ſeem to collect their flame into a globe of light, and thus gradually leſſen, till they are quite extinguiſhed. From this alſo, the miners frequently eſcape; however, ſuch as have the misfortune to be caught in it, either ſwoon away, and are ſuffocated, or ſlowly recover in exceſſive agonies. Here is alſo a third, called the fulminating damp, much more dangerous than either of the former, as it ſtrikes down all before it, like a flaſh of gunpowder, without giving any warning of its approach. But there is ſtill another, more deadly than all the reſt, which is found in thoſe places where the vapour has been long confined, and has been, by ſome accident, ſet free. The air ruſhing out from thence, always goes upon deadly errands; and ſcarce any eſcape to deſcribe the ſymptoms of its operations.

Some colliers in Scotland, working near an old mine that had been long cloſed up, happened inadvertently to open an hole into it, from the pit where they were then employed.

By

By great good fortune, they at that time perceived their error, and inſtantly fled for their lives. The next day, however, they were reſolved to renew their work in the ſame pit, and eight of them ventured down, without any great apprehenſions; but they had ſcarce got to the bottom of the ſtairs that led to the pit, but coming within the vapour, they all inſtantly dropped down dead, as if they had been ſhot. Amongſt theſe unfortunate poor men, there was one whoſe wife was informed that he was ſtifled in the mine; and as he happened to be next the entrance, ſhe ſo far ventured down as to ſee where he lay. As ſhe approached the place, the ſight of her huſband inſpired her with a deſire to reſcue him, if poſſible, from that dreadful ſituation; though a little reflection might have ſhewn her it was then too late. But nothing could deter her; ſhe ventured forward, and had ſcarce touched him with her hand, when the damp prevailed, and the miſguided, but faithful creature, fell dead by his ſide.

Thus, the vapours found beneath the ſurface of the earth, are very various in their effects upon the conſtitution: and they are not leſs in their appearances. There are many kinds that ſeemingly are no way prejudicial to health, but in which the workmen breathe freely; and yet in theſe, if a

lighted candle be introduced, they immediately take fire, and the whole cavern at once becomes one furnace of flame. In mines, therefore, ſubject to damps of this kind, they are obliged to have recourſe to a very peculiar contrivance to ſupply ſufficient light for their operations. This is by a great wheel; the circumference of which is beſet with flints, which ſtriking againſt ſteels placed for that purpoſe at the extremity, a ſtream of fire is produced, which affords light enough; and yet which does not ſet fire to the mineral vapour.

Of this kind are the vapours of the mines about Briſtol: on the contrary, in other mines, a ſingle ſpark ſtruck out from the colliſion of flint and ſteel, would ſet the whole ſhaft in a flame. In ſuch, therefore, every precaution is uſed to avoid a colliſion; the workmen making uſe only of wooden inſtruments in digging; and being cautious before they enter the mine, to take out even the nails from their ſhoes. Whence this ſtrange difference ſhould ariſe, that the vapours of ſome mines catch fire with a ſpark, and others only with a flame, is a queſtion that we muſt be content to leave in obſcurity, till we know more of the nature both of mineral vapour and of fire. This only we may obſerve, that gunpowder will readily fire with

with a ſpark, but not with the flame of a candle: on the other hand, ſpirits of wine will flame with a candle, but not with a ſpark; but even here the cauſe of this difference, as yet, remains a ſecret.

As from this account of mines, it appears that the internal parts of the globe are filled with vapours of different kinds, it is not ſurprizing, that they ſhould at different times reach the ſurface, and there put on various appearances. In fact, much of the ſalubrity, and much of the unwholſomeneſs of climates and ſoils, is to be aſcribed to theſe vapours, which make their way from the bowels of the earth upwards, and refreſh or taint the air with their exhalations. Salt mines being naturally cold *, ſend forth a degree of coldneſs to the external air, to comfort and refreſh it: on the contrary, metallic mines are known, not only to warm it with their exhalations, but often to deſtroy all kinds of vegetation by their volatile corroſive fumes. In ſome mines denſe vapours are plainly perceived iſſuing from their mouths, and ſenſibly warm to the touch. In ſome places, neither ſnow nor ice will continue on the ground that covers a mine; and over others the fields are

* Phil. Trans. vol. ii. p. 523.

found deſtitute of verdure †. The inhabitants, alſo, are rendered dreadfully ſenſible of theſe ſubterraneous exhalations, being affected with ſuch a variety of evils proceeding entirely from this cauſe, that books have been profeſſedly written upon this claſs of diſorders.

Nor are theſe vapours which thus eſcape to the ſurface of the earth, entirely unconfined; for they are frequently, in a manner, circumſcribed to a ſpot: the grotto Del Cane, near Naples, is an inſtance of this; the noxious effects of which have made that cavern ſo famous. This grotto, which has ſo much employed the antient travellers, lies within four miles of Naples, and is ſituated near a large lake of clear and wholeſome water ‡. Nothing can exceed the beauty of the landſcape which this lake affords; being ſurrounded with hills covered with foreſts of the moſt beautiful verdure, and the whole bearing a kind of amphitheatrical appearance. However, this region, beautiful as it appears, is almoſt entirely uninhabited; the few peaſants that neceſſity compels to reſide there, looking quite conſumptive and ghaſtly, from the poiſonous exhalations that riſe

† Boyle, vol. iii. p. 238.
‡ Kircher Mund. Subt. vol. i. p. 191.

from

from the earth. The famous grotto lies on the ſide of an hill, near which place a peaſant reſides, who keeps a number of dogs for the purpoſe of ſhewing the experiment to the curious. Theſe poor animals always ſeem perfectly ſenſible of the approach of a ſtranger, and endeavour to get out of the way. However, their attempts being perceived, they are taken and brought to the grotto; the noxious effects of which they have ſo frequently experienced. Upon entering this place, which is a little cave, or hole rather, dug into the hill, about eight feet high and twelve feet long, the obſerver can ſee no viſible marks of its peſtilential vapour; only to about a foot from the bottom, the wall ſeems to be tinged with a colour reſembling that which is given by ſtagnant waters. When the dog, this poor philoſophical martyr, as ſome have called him, is held above this mark, he does not ſeem to feel the ſmalleſt inconvenience; but when his head is thruſt down lower, he ſtruggles to get free for a little; but in the ſpace of four or five minutes he ſeems to loſe all ſenſation, and is taken out ſeemingly without life. Being plunged in the neighbouring lake, he quickly recovers, and is permitted

to

to run home ſeemingly without the ſmalleſt injury.

This vapour, which thus for a time ſuffocates, is of the humid kind, as it extinguiſhes a torch, and ſullies a looking-glaſs; but there are other vapours perfectly inflammable, and that only require the approach of a candle to ſet them blazing. Of this kind was the burning well at Broſely, which is now ſtopped up; the vapour of which, when a candle was brought within about a foot of the ſurface of the water, caught flame like ſpirits of wine, and continued blazing for ſeveral hours after. Of this kind, alſo, are the perpetual fires in the kingdom of Perſia. In that province, where the worſhippers of fire hold their chief myſteries, the whole ſurface of the earth, for ſome extent, ſeems impregnated with inflammable vapours. A reed ſtuck into the ground continues to burn like a flambeaux, an hole made beneath the ſurface of the earth, inſtantly becomes a furnace anſwering all the purpoſes of a culinary fire. There they make lime by merely burying the ſtones in the earth, and watch with veneration the appearances of a flame that has not been extinguiſhed for times immemorial. How different are men in various climates!

Jnº Lodge Sculp.

Volcano.

climates! this deluded people worſhip theſe vapours as a deity, which in other parts of the world are conſidered as one of the greateſt evils.

CHAP. IX.

Of Volcanoes and Earthquakes.

MINES and caverns, as we have ſaid, reach but a very little way under the ſurface of the earth, and we have hitherto had no opportunities of exploring further. Without all doubt the wonders that are ſtill unknown ſurpaſs thoſe that have been repreſented, as there are depths of thouſands of miles whieh are hidden from our enquiry. The only tidings we have from thoſe unfathomable regions are by means of volcanoes, thoſe burning mountains that ſeem to diſcharge their materials from the loweſt abyſſes of the earth*. A volcano may be conſidered as a canon of immenſe ſize, the mouth of which is often near two miles in circumference. From this dreadful apperture are diſcharged torrents of flame and

* Buffon, vol. i. p. 291.

ſulphur,

ſulphur, and rivers of melted metal. Whole clouds of ſmoke and aſhes, with rocks of enormous ſize, are diſcharged to many miles diſtance; ſo that the force of the moſt powerful artillery, is but as a breeze agitating a feather in compariſon. In the deluge of fire and melted matter which runs down the ſides of the mountain, whole cities are ſometimes ſwallowed up and conſumed. Thoſe rivers of liquid fire are ſometimes two hundred feet deep; and, when they harden, frequently form conſiderable hills. Nor is the danger of theſe confined to the eruption only: but the force of the internal fire ſtruggling for vent, frequently produces earthquakes through the whole region where the volcano is ſituated. So dreadful have been theſe appearances, that men's terrors have added new horrors to the ſcene, and they have regarded as prodigies, what we know to be the reſult of natural cauſes. Some philoſophers have conſidered them as vents communicating with the fires of the center, and the ignorant as the mouths of hell itſelf. Aſtoniſhment produces fear, and fear ſuperſtition: the inhabitants of Iceland believe the bellowings of Hecla are nothing elſe but the cries of the damned, and that its eruptions are contrived to encreaſe their tortures.

But

But if we regard this aſtoniſhing ſcene of terror with a more tranquil and inquiſitive eye, we ſhall find that theſe conflagrations are produced by very obvious and natural cauſes. We have already been apprized of the various mineral ſubſtances in the boſom of the earth, and their aptneſs to burſt out into flames. Marcaſites and pyrites, in particular, by being humefied with water, or air, contract this heat, and often endeavour to expand with irreſiſtible exploſion. Theſe, therefore, being lodged in the depths of the earth, or in the boſom of mountains, and being either waſhed by the accidental influx of waters below, or fanned by air, inſinuating itſelf through perpendicular fiſſures from above, take fire at firſt by only heaving in earthquakes, but at length by burſting through every obſtacle, and making their dreadful diſcharge in a volcano.

Theſe volcanoes are found in all parts of the earth: in Europe there are three that are very remarkable; Ætna in Sicily, Veſuvius in Italy, and Hecla in Iceland. Ætna has been a volcano for ages immemorial. Its eruptions are very violent, and its diſcharge has been known to cover the earth ſixty-eight feet deep. In the year 1537, an eruption of this mountain produced an earthquake through the whole iſland, for twelve days,

days, overturned many houſes, and at laſt formed a new aperture which overwhelmed all within five leagues round. The cinders thrown up were driven into Italy, and its burnings were ſeen at Malta at the diſtance of ſixty leagues. There is nothing more awful, ſays Kircher, than the eruptions of this mountain, and nothing more dangerous than attempting to examine its appearances, even long after the eruption has ceaſed. As we attempt to clamber up its ſteepy ſides, every ſtep we take upward, the feet ſink back half way. Upon arriving near the ſummit, aſhes and ſnow, with an ill aſſorted conjunction, preſent nothing but objects of deſolation. Nor is this the worſt, for, as all the places are covered over, many caverns are entirely hidden from the ſight, into which, if the enquirer happens to fall, he ſinks to the bottom, and meets inevitable deſtruction. Upon coming to the edge of the great crater, nothing can ſufficiently repreſent the tremendous magnificence of the ſcene. A gulph two miles over, and ſo deep that no bottom can be ſeen; on the ſides pyramidical rocks ſtarting out between apertures that emit ſmoke and flame; all this accompanied with a ſound that never ceaſes, louder than thunder, ſtrikes the bold with horror, and the religious with veneration

ration of Him that has power to controul its burnings.

In the deſcriptions of Veſuvius, or Hecla, we ſhall find ſcarce any thing but a repetition of the ſame terrible objects, but rather leſſened, as theſe mountains are not ſo large as the former. The crater of Veſuvius is but a mile acroſs, according to the ſame author; whereas that of Ætna is two. On this particular, however, we muſt place no dependance, as theſe caverns every day alter; being leſſened by the mountains ſinking in at one eruption, and enlarged by the fury of another. It is not one of the leaſt remarkable particulars reſpecting Veſuvius, that Pliny the naturaliſt was ſuffocated in one of its eruptions; for his curioſity impelling him too near, he found himſelf involved in ſmoke and cinders when it was too late to retire; and his companions hardly eſcaped to give an account of the miſfortune. It was in that dreadful eruption that the city of Herculaneum was overwhelmed; the ruins of which have been lately diſcovered at ſixty feet diſtance below the ſurface, and, what is ſtill more remarkable, forty feet below the bed of the ſea. One of the moſt remarkable eruptions of this mountain was in the year 1707, which is finely deſcribed by Valetta, a part of whoſe

whoſe deſcription I ſhall beg leave to tranſlate.

"Towards the latter end of ſummer, in the year 1707, the mount Veſuvius, that had for a long time been ſilent, now began to give ſome ſigns of commotion. Little more than internal murmurs at firſt were heard, that ſeemed to contend within the loweſt depths of the mountain; no flame, nor even any ſmoak was as yet ſeen. Soon after ſome ſmoak appeared by day, and a flame by night, which ſeemed to brighten all the campania. At intervals alſo it ſhot off ſubſtances with a ſound very like that of artillery, but which, even at ſo great a diſtance as we were at, infinitely exceeded them in greatneſs. Soon after it began to throw up aſhes, which becoming the ſport of the winds, fell at great diſtances, and ſome many miles. To this ſucceeded ſhowers of ſtones, which killed many of the inhabitants of the valley, but made a dreadful ravage among the cattle. Soon after a torrent of burning matter began to roll down the ſides of the mountain, at firſt with a ſlow and gentle motion, but ſoon with encreaſed celerity. The matter thus poured out, when cold, ſeemed, upon inſpection, to be of vitrified earth, the whole united into a maſs of more than ſtony hardneſs. But what was particularly obſervable

was,

was, that upon the whole ſurface of theſe melted materials, a light ſpongy ſtone ſeemed to float, while the lower body was of the hardeſt ſubſtance, of which our roads are uſually made. Hitherto there were no appearances but what had been often remarked before; but on the third or fourth day, ſeeming flaſhes of lightening were ſhot forth from the mouth of the mountain, with a noiſe far exceeding the loudeſt thunder. Theſe flaſhes, in colour and brightneſs, reſembled what we uſually ſee in tempeſts, but they aſſumed a more twiſted and ſerpentine form. After this followed ſuch clouds of ſmoak and aſhes, that the whole city of Naples, in the midſt of the day, was involved in nocturnal darkneſs, and the neareſt friends were unable to diſtinguiſh each other in this frightful gloom. If any perſon attempted to ſtir out without torch-light he was obliged to return, and every part of the city was filled with ſupplications and terror; at length, after a continuance of ſome hours, about one o'clock at midnight, the wind blowing from the north, the ſtars began to be ſeen; the heavens, though it was night, began to grow brighter; and the eruptions, after a continuance of fifteen days, to leſſen. The torrent of melted matter was ſeen to extend from the mountain down to the ſhore; the people

people began to return to their former dwellings, and the whole face of nature to reſume its former appearance."

The famous biſhop Berkley gives an account of one of theſe eruptions in a manner ſomething different from the former. * "In the year 1717, and the middle of April, with much difficulty I reached the top of mount Veſuvius, in which I ſaw a vaſt aperture full of ſmoak, which hindered me from ſeeing its depth and figure. I heard within that horrid gulph certain extraordinary ſounds, which ſeemed to proceed from the bowels of the mountain, a ſort of murmuring, ſighing, daſhing ſound, and between whiles a noiſe like that of thunder or cannon, with a clattering like that of tiles falling from the tops of houſes into the ſtreets. Sometimes, as the wind changed, the ſmoak grew thinner, diſcovering a very ruddy flame, and the circumference of the crater ſtreaked with red and ſeveral ſhades of yellow. After an hour's ſtay, the ſmoak being moved by the wind, gave us ſhort and partial proſpects of the great hollow; in the flat bottom of which I could diſcern two furnaces almoſt contiguous; that on the left ſeeming about three yards over, glowing with ruddy flame; and

* Phil. Tranſ. vol. ii. p. 209.

throw-

throwing up red hot ſtones, with an hideous noiſe, which, as they fell back, cauſed the clattering already taken notice of. May 8, in the morning, I aſcended the top of Veſuvius a ſecond time, and found a different face of things. The ſmoak aſcending upright, gave a full proſpect of the crater, which, as I could judge, was about a mile in circumference, and an hundred yards deep. A conical mount had been formed ſince my laſt viſit in the middle of the bottom, which I could ſee was made by the ſtones, thrown up and fallen back again into the crater. In this new hill remained the two furnaces already mentioned. The one was ſeen to throw up every three or four minutes, with a dreadful ſound, a vaſt number of red hot ſtones, at leaſt three hundred feet higher than my head, as I ſtood upon the brink; but as there was no wind, they fell perpendicularly back from whence they had been diſcharged. The other was filled with red hot liquid matter, like that in the furnace of a glaſs-houſe; raging and working like the waves of the ſea, with a ſhort abrupt noiſe. This matter would ſometimes boil over, and run down the ſide of the conical hill, appearing at firſt red hot, but changing colour as it hardened and cooled. Had the wind driven in our faces, we had been in no

ſmall

ſmall danger of ſtifling by the ſulphureous ſmoak, or being killed by the maſſes of melted minerals, that were ſhot from the bottom. But as the wind was favourable, I had an opportunity of ſurveying this amazing ſcene for above an hour and an half together. On the fifth of June, after an horrid noiſe, the mountain was ſeen at Naples to work over; and about three days after, its thunders were renewed ſo, that not only the windows in the city, but all the houſes ſhook. From that time it continued to overflow, and ſometimes at night were ſeen columns of fire ſhooting upward from its ſummit. On the tenth, when all was thought to be over, the mountain again renewed its terrors, roaring and raging moſt violently. One cannot form a juſter idea of the noiſe, in the moſt violent fits of it, than by imagining a mixed ſound, made up of the raging of a tempeſt, the murmur of a troubled ſea, and the roaring of thunder and artillery, confuſed all together. Though we heard this at the diſtance of twelve miles, yet it was very terrible. I therefore reſolved to approach nearer to the mountain; and, accordingly, three or four of us got into a boat, and were ſet aſhore at a little town, ſituated at the foot of the mountain. From thence we rode

about

about four or five miles, before we came to the torrent of fire that was deſcending from the ſide of the volcano; and here the roaring grew exceeding loud and terrible as we approached. I obſerved a mixture of colours in the cloud, above the crater, green, yellow, red, blue. There was likewiſe a ruddy diſmal light in the air, over that tract where the burning river flowed. Theſe circumſtances, ſet off and augmented by the horror of the night, made a ſcene the moſt uncommon and aſtoniſhing I ever ſaw; which ſtill encreaſed as we approached the burning river. Imagine a vaſt torrent of liquid fire, rolling from the top, down the ſide of the mountain, and with irreſiſtible fury bearing down and conſuming vines, olives, and houſes; and divided into different channels, according to the inequalities of the mountain. The largeſt ſtream ſeemed half a mile broad at leaſt, and five miles long. I walked ſo far before my companions up the mountain, along the ſide of the river of fire, that I was obliged to retire in great haſte, the ſulphureous ſtream having ſurprized me, and almoſt taken away my breath. During our return, which was about three o'clock in the morning, the roaring of the mountain was heard all the way, while we obſerved it throwing up

huge ſpouts of fire and burning ſtones, which falling, reſembled the ſtars in a rocket. Sometimes I obſerved two or three diſtinct columns of flame, and ſometimes one only that was large enough to fill the whole crater. Theſe burning columns, and fiery ſtones, ſeemed to be ſhot a thouſand feet perpendicular above the ſummit of the volcano: and in this manner the mountain continued raging for ſix or eight days after. On the eighteenth of the ſame month the whole appearance ended, and the mountain remained perfectly quiet, without any viſible ſmoke or flame."

The matter which is found to roll down from the mouth of all volcanoes in general, reſembles the droſs that is thrown from a ſmith's forge. But it is different, perhaps, in various parts of the globe; for, as we have already ſaid, there is not a quarter of the world that has not its volcanoes. In Aſia, particularly in the iſlands of the Indian ocean, there are many. One of the moſt famous is that of Albouras, near Mount Taurus, the ſummit of which is continually on fire, and covers the whole adjacent country with aſhes. In the iſland of Ternate there is a volcano, which ſome travellers aſſert, burns moſt furiouſly in the times of the equinoxes, becauſe of the winds which then

then contribute to encreaſe the flames. In the Molucca iſlands there are many burning mountains; they are alſo ſeen in Japan, and the iſlands adjacent; and in Java and Sumatra, as well as in other of the Philippine iſlands. In Africa there is a cavern, near Fez, which continually ſends forth either ſmoke or flames. In the Cape de Verde iſlands, one of them, called the Iſland del Fuego, continually burns; and the Portugueſe, who frequently attempted a ſettlement there, have as often been obliged to deſiſt. The Peak of Teneriffe is, as every body knows, a volcano that ſeldom deſiſts from eruptions. But of all parts of the earth, America is the place where thoſe dreadful irregularities of nature are the moſt conſpicuous. Veſuvius, and Ætna itſelf, are but mere fire-works, in compariſon to the burning mountains of the Andes; which, as they are the higheſt mountains of the world, ſo alſo are they the moſt formidable for their eruptions. The mountain of Arequipa in Peru, is one of the moſt celebrated; Caraffa, and Malahallo, are very conſiderable; but that of Cotopaxi, in the province of Quito, exceeds any thing we have hitherto read or heard of. The mountain of Cotopaxi, as deſcribed by Ulloa*, is more than three

* Ulloa, vol. i. p. 142.

miles perpendicular from the ſea; and it became a volcano at the time of the Spaniards firſt arrival in that country. A new eruption of it happened in the year 1743, having been ſome days preceded by a continual roaring in its bowels. The ſound of one of theſe mountains is not like that of the volcanoes in Europe, confined to a province, but is heard at an hundred and fifty miles diſtance*. "An aperture was made in the ſummit of this immenſe mountain; and three more about equal heights, near the middle of its declivity, which was at that time buried under prodigious maſſes of ſnow. The ignited ſubſtances ejected on that occaſion, mixed with a prodigious quantity of ice and ſnow, melting amidſt the flames, were carried down with ſuch aſtoniſhing rapidity, that in an inſtant the valley from Callo to Latacunga was overflowed; and beſides its ravages in bearing down the houſes of the Indians, and other poor inhabitants, great numbers of people loſt their lives. The river of Latacunga was the channel of this terrible flood; till being too ſmall for receiving ſuch a prodigious current, it overflowed the adjacent country, like a vaſt lake, near the town, and carried away all the buildings within its reach. The

* Ulloa, vol. i. p. 442.

inhabitants

inhabitants retired into a ſpot of higher ground behind the town, of which thoſe parts which ſtood within the limits of the current were totally deſtroyed. The dread of ſtill greater devaſtations did not ſubſide for three days; during which, the volcano ejected cinders, while torrents of melted ice and ſnow poured down its ſides. The eruption laſted ſeveral days, and was accompanied with terrible roarings of the wind, ruſhing through the volcano ſtill louder than the former rumblings in its bowels. At laſt all was quiet, neither fire nor ſmoke to be ſeen, nor noiſe to be heard; till in the enſuing year, the flames again appeared with recruited violence, forcing their paſſage through ſeveral other parts of the mountain, ſo that in clear nights the flames being reflected by the tranſparent ice, formed an awfully magnificent illumination."

Such is the appearance and the effect of thoſe fires which proceed from the more inward receſſes of the earth; for that they generally come from deeper regions than man has hitherto explored, I cannot avoid thinking, contrary to the opinion of Mr. Buffon, who ſuppoſes them rooted but a very little way below the bed of the mountain. We can never ſuppoſe, ſays this great naturaliſt, that theſe ſubſtances are ejected from any great

great diſtance below, if we only conſider the great force already required to fling them up to ſuch vaſt heights above the mouth of the mountain; if we conſider the ſubſtances thrown up, which we ſhall find upon inſpection to be the ſame with thoſe of the mountain below; if we take into our conſideration, that air is always neceſſary to keep up the flame; but, moſt of all, if we attend to one circumſtance, which is, that if theſe ſubſtances were exploded from a vaſt depth below, the ſame force required to ſhoot them up ſo high, would act againſt the ſides of the volcano, and tear the whole mountain in pieces. To all this ſpecious reaſoning, particular anſwers might eaſily be given; as that the length of the funnel encreaſes the force of the exploſion; that the ſides of the funnel are actually often burſt with the great violence of the flame; that air may be ſuppoſed at depths at leaſt as far as the perpendicular fiſſures deſcend. But the beſt anſwer is a well-known fact; namely, that the quantity of matter diſcharged from Ætna alone, is ſuppoſed, upon a moderate computation, to exceed twenty times the original bulk of the mountain *. The greateſt part of Sicily ſeems covered

* Kircher, Mund. Subt. vol. 1. p. 202.

with

with its eruptions. The inhabitants of Catanea have found, at the diſtance of ſeveral miles, ſtreets and houſes, ſixty feet deep, overwhelmed by the lava or matter it has diſcharged. But what is ſtill more remarkable, the walls of theſe very houſes have been built of materials evidently thrown up by the mountain. The inference from all this is very obvious; that the matter thus exploded cannot belong to the mountain itſelf; otherwiſe, it would have been quickly conſumed; it cannot be derived from moderate depths, ſince its amazing quantity evinces, that all the places near the bottom muſt have long ſince been exhauſted; nor can it have an extenſive, and, if I may ſo call it, a ſuperficial ſpread, for then the country round would be quickly undermined; it muſt, therefore, be ſupplied from the deeper regions of the earth; thoſe undiſcovered tracts where the Deity performs his wonders in ſolitude, ſatisfied with ſelf-approbation!

CHAP. X.

Of Earthquakes.

HAVING given the theory of volcanoes, we have in ſome meaſure given alſo that of earthquakes. They both ſeem to proceed from the ſame cauſe, only with this difference, that the fury of the volcano is ſpent in the eruption, that of an earthquake ſpreads wider and acts more fatally by being confined. The volcano only affrights a province, earthquakes have laid whole kingdoms in ruin.

Philoſophers * have taken ſome pains to diſtinguiſh between the various kinds of earthquakes, ſuch as the tremulous, the pulſative, the perpendicular, and the inclined; but theſe are rather the diſtinctions of art than of nature, mere accidental differences ariſing from the ſituation of the country or of the cauſe. If, for inſtance, the confined fire acts directly under a province or a town, it will heave the earth perpendicularly upward, and produce a *perpendicular* earthquake. If it acts at a diſtance, it

* Ariſtotle, Agricola, Buffon.

will

will raiſe that tract obliquely, and thus the inhabitants will perceive an *inclined* one.

Nor does it ſeem to me that there is much greater reaſon for Mr. Buffon's diſtinction of earthquakes. One kind of which he ſuppoſes * to be produced by fire in the manner of volcanoes, and confined to but a very narrow circumference. The other kind he aſcribes to the ſtruggles of confined air, expanded by heat in the bowels of the earth, and endeavouring to get free. For how do theſe two cauſes differ? Fire is an agent of no power whatſoever without air. It is the air, which being at firſt compreſt, and then dilated in a cannon, that drives the ball with ſuch force. It is the air ſtruggling for vent in a volcano, that throws up its contents to ſuch vaſt heights. In ſhort, it is the air confined in the bowels of the earth, and acquiring elaſticity by heat, that produces all thoſe appearances which are generally aſcribed to the operation of fire. When, therefore, we are told that there are two cauſes of earthquakes, we only learn, that a greater or ſmaller quantity of heat produces thoſe terrible effects; for air is the only active operator in either.

Some philoſophers, however, have been willing to give the air as great a ſhare in

* Buffon, vol. ii. 328.

pro-

producing theſe terrible efforts as they could; and magnifying its powers have called in but a very moderate degree of heat to put it in action. Although experience tells us that the earth is full of inflammable materials, and that fires are produced wherever we deſcend; although it tells us that thoſe countries, where there are volcanoes, are moſt ſubject to earthquakes, yet they ſtep out of the way, and ſo find a new ſolution. Theſe only allow but juſt heat enough to produce the moſt dreadful phœnomena, and backing their aſſertions with long calculations, give theory an air of demonſtration. Mr. Amontons * has been particularly ſparing of the internal heat in this reſpect; and has ſhewn, perhaps accurately enough, that a very moderate degree of heat may ſuffice to give the air amazing powers of expanſion.

It is amazing enough, however, to trace the progreſs of a philoſophical fancy let looſe in imaginary ſpeculations. They run thus: "A very moderate degree of heat may bring the air into a condition capable of producing earthquakes; for the air at the depth of forty-three thouſand five hundred and twenty-eight fathom below the ſurface of the earth, becomes almoſt as heavy as quick-

* Memoires de l'Academie de Sciences, An. 1703.

ſilver.

ſilver. This, however, is but a very ſlight depth in compariſon of the diſtance to the center, and is ſcarce a ſeventieth part of the way. The air, therefore, at the center muſt be infinitely heavier than mercury, or any body that we know of. This granted, we ſhall take ſomething more, and ſay, that it is very probable there is nothing but air at the center. Now let us ſuppoſe this air heated, by ſome means, even to the degree of boiling water, as we have proved that the denſity of the air is here very great, its elaſticity muſt be in proportion: an heat, therefore, which at the ſurface of the earth would have produced but a ſlight expanſive force, muſt at the center produce one very extraordinary, and, in ſhort, be perfectly irreſiſtible. Hence this force may with great eaſe produce earthquakes; and if encreaſed it may convulſe the globe; it may (by only adding figures enough to the calculation) deſtroy the ſolar ſyſtem, and even the fixed ſtars themſelves." Theſe reveries generally produce nothing; for, as I have ever obſerved, encreaſed calculations, while they ſeem to tire the memory, give the reaſoning faculty perfect repoſe.

However, as earthquakes are the moſt formidable miniſters of nature, it is not to be wondered

wondered that a multitude of writers have been curiouſly employed in their conſideration. Woodward has aſcribed the cauſe to a ſtoppage of the waters below the earth's ſurface by ſome accident. Theſe being thus accumulated, and yet acted upon by fires, which he ſuppoſes ſtill deeper, both contribute to heave up the earth upon their boſom. This he thinks accounts for the lakes of water produced in an earthquake, as well as for the fires that ſometimes burſt from the earth's ſurface upon thoſe dreadful occaſions. There are others ſtill who have ſuppoſed that the earth may be itſelf the cauſe of its own convulſions. When, ſay they, the roots or baſis of ſome large tract is worn away by a fluid underneath, the earth ſinking therein, its weight occaſions a tremor of the adjacent parts, ſometimes producing a noiſe, and ſometimes an inundation of water. Not to tire the reader with an hiſtory of opinions inſtead of facts, ſome have aſcribed them to electricity, and ſome to the ſame cauſes that produce thunder.

It would be tedious, therefore, to give all the various opinions that have employed the ſpeculative upon this ſubject. The activity of the internal heat ſeems alone ſufficient to account for every appearance that attends

thefe tremendous irregularities of nature. To conceive this diftinctly, let us fuppofe at fome vaft diftance under the earth, large quantities of inflammable matter, pyrites, bitumens, and marcafites difpofed, and only waiting for the afperfion of water, or the humidity of the air, to put their fires in motion: at laft, this dreadful mixture arrives; waters find their way into thofe depths, through the perpendicular fiffures; or air infinuates itfelf through the fame minute apertures: ftrait new appearances enfue: thofe fubftances, which for ages before lay dormant, now conceive new apparent qualities; they grow hot, produce new air, and only want room for expanfion, However, the narrow apertures by which the air or water had at firft admiffion, are now clofed up; yet as new air is continually generated, and as the heat every moment gives this air new elafticity, it at length burfts, and dilates all round; and, in its ftruggles to get free, throws all above it into fimilar convulfions. Thus an earthquake is produced, more or lefs extenfive, according to the depth or the greatnefs of the cauſe.

But before we proceed with the cauſes, let us take a ſhort view of the appearances which have attended the moſt remarkable earthquakes. By theſe we ſhall ſee how far the

the theoriſt correſponds with the hiſtorian. The greateſt we find in antiquity, is that mentioned by Pliny*, in which twelve cities in Aſia Minor were ſwallowed up in one night: he tells us alſo of another, near the lake Thraſymene, which was not perceived by the armies of the Carthaginians and Romans, that were then engaged near that lake, although it ſhook the greateſt part of Italy. In another place † he gives the following account of an earthquake of an extraordinary kind. "When Lucius Marcus, and Sextus Julius, were conſuls, there appeared a very ſtrange prodigy of the earth, (as I have read in the books of Ætruſcan diſcipline) which happened in the province of Mutina. Two mountains ſhocked againſt each other, approaching and retiring with the moſt dreadful noiſe. They, at the ſame time, and in the midſt of the day, appeared to caſt forth fire and ſmoke, while a vaſt number of Roman knights and travellers from the Æmilian way, ſtood and continued amazed ſpectators. Several towns were deſtroyed by this ſhock; and all the animals that were near them were killed." In the times of Trajan, the city of Antioch, and a great part of the adjacent country, was buried by an earthquake.

* Plin. lib. ii. cap. 86. † Ibid. lib. iii. cap. 85.

About

About three hundred years after, in the times of Juſtinian, it was once more deſtroyed, together with forty thouſand inhabitants: and, after an interval of ſixty years, the ſame ill-fated city was a third time overturned, with the loſs of not leſs than ſixty thouſand ſouls. In the year 1182, moſt of the cities of Syria, and the kingdom of Jeruſalem, were deſtroyed by the ſame accident. In the year 1594, the Italian hiſtorians deſcribe the earthquake at Puteoli, which cauſed the ſea to retire two hundred yards from its former bed.

But one of thoſe moſt particularly deſcribed in hiſtory, is that of the year 1693; the damages of which were chiefly felt in Sicily, but its motion perceived in Germany, France, and England. It extended to a circumference of two thouſand ſix hundred leagues; chiefly affecting the ſea coaſts, and great rivers; more perceivable alſo upon the mountains than in the valleys. Its motions were ſo rapid, that thoſe who lay at their length, were toſſed from ſide to ſide, as upon a rolling billow *. The walls were daſhed from their foundations; and no leſs than fifty-four cities, with an incredible number of villages, were either deſtroyed or greatly damaged. The city of Catanea, in particular, was ut-

* Phil. Tranſ.

terly

terly overthrown. A traveller, who was on his way thither, at the diſtance of ſome miles, perceived a black cloud, like night, hanging over the place. The ſea, all of a ſudden, began to roar; Mount Ætna to ſend forth great ſpires of flame; and ſoon after a ſhock enſued, with a noiſe as if all the artillery in the world had been at once diſcharged. Our traveller, being obliged to alight inſtantly, felt himſelf raiſed a foot from the ground; and turning his eyes to the city, he with amazement ſaw nothing but a thick cloud of duſt in the air. The birds flew about aſtoniſhed; the ſun was darkened; the beaſts ran howling from the hills; and, although the ſhock did not continue above three minutes, yet near nineteen thouſand of the inhabitants of Sicily periſhed in the ruins. Catanea, to which city the deſcriber was travelling, ſeemed the principal ſcene of ruin; its place only was to be found; and not a footſtep of its former magnificence was to be ſeen remaining.

The earthquake which happened in Jamaica, in 1692, was very terrible, and its deſcription ſufficiently minute. "In two minutes time it deſtroyed the town of Portugal, and ſunk the houſes in a gulph forty fathoms deep. It was attended with an hollow rumbling noiſe, like that of thunder; and,

and, in leſs than a minute, three parts of the houſes, and their inhabitants, were all ſunk quite under water. While they were thus ſwallowed up on one ſide of the ſtreet, on the other, the houſes were thrown into heaps; the ſand of the ſtreet riſing like the waves of the ſea, lifting up thoſe that ſtood upon it, and immediately overwhelming them in pits. All the wells diſcharged their waters with the moſt vehement agitation. The ſea felt an equal ſhare of turbulence, and, burſting over its mounds, deluged all that came in its way. The fiſſures of the earth were, in ſome places, ſo great, that one of the ſtreets appeared twice as broad as formerly. In many places, however, it opened and cloſed again, and continued this agitation for ſome time. Of theſe openings, two or three hundred might be ſeen at a time; in ſome whereof the people were ſwallowed up; in others, the earth cloſing, caught them by the middle, and thus cruſhed them inſtantly to death. Other openings, ſtill more dreadful than the reſt, ſwallowed up whole ſtreets; and others, more formidable ſtill, ſpouted up whole cataracts of water, drowning ſuch as the earthquake had ſpared. The whole was attended with the moſt noiſome ſtench; while the thundering of the diſtant falling mountains, the whole ſky overcaſt

with a duſky gloom, and the cruſh of falling habitations, gave unſpeakable horror to the ſcene. After this dreadful calamity was over, the whole iſland ſeemed converted into a ſcene of deſolation; ſcarce a planter's houſe was left ſtanding; almoſt all were ſwallowed up; houſes, people, trees, ſhared one univerſal ruin; and, in their places appeared great pools of water, which, when dried up by the ſun, left only a plain of barren ſand, without any veſtige of former inhabitants. Moſt of the rivers, during the earthquake, were ſtopt up by the falling in of the mountains; and it was not till after ſome time that they made themſelves new channels. The mountains ſeemed particularly attacked by the force of the ſhock; and it was ſuppoſed that the principal ſeat of the concuſſion was among them. Thoſe who were ſaved, got on board ſhips in the harbour; where many remained above two months, the ſhocks continuing during that interval with more or leſs violence every day."

As this deſcription ſeems to exhibit all the appearances that uſually make up the catalogue of terrors belonging to an earthquake, I will ſuppreſs the detail of that which happened at Liſbon, in our own times, and which is too recent to require a deſcription. In fact, there are few particulars in the ac-

counts

counts of thoſe who were preſent at that ſcene of deſolation, that we have not more minutely and accurately tranſmitted to us by former writers, whoſe narratives I have for that reaſon preferred. I will, therefore, cloſe this deſcription of human calamities, with the account of the dreadful earthquake at Calabria, in 1638. It is related by the celebrated Father Kircher, as it happened while he was on his journey to viſit Mount Ætna, and the reſt of the wonders that lie towards the ſouth of Italy. I need ſcarce inform the reader that Kircher is conſidered, by ſcholars, as one of the greateſt prodigies of learning.

" Having hired a boat, in company with four more, two friars of the order of St. Francis, and two ſeculars, we launched, on the twenty fourth of March, from the harbour of Meſſina, in Sicily, and arrived, the ſame day, at the promontory of Pelorus. Our deſtination was for the city of Euphemia, in Calabria, where we had ſome buſineſs to tranſact, and where we deſigned to tarry for ſome time. However, Providence ſeemed willing to croſs our deſign; for we were obliged to continue for three days at Pelorus, upon account of the weather; and though we often put to ſea, yet we were as often driven back. At length, however, wearied

with the delay, we reſolved to proſecute our voyage; and, although the ſea ſeemed more than uſually agitated, yet we ventured forward. The gulph of Charybdis, which we approached, ſeemed whirled round in ſuch a manner as to form a vaſt hollow, verging to a point in the center. Proceeding onward, and turning my eyes to Ætna, I ſaw it caſt forth large volumes of ſmoke, of mountainous ſizes, which entirely covered the whole iſland, and blotted out the very ſhores from my view. This, together with the dreadful noiſe, and the ſulphureous ſtench, which was ſtrongly perceived, filled me with apprehenſions that ſome more dreadful calamity was impending. The ſea itſelf ſeemed to wear a very unuſual appearance; thoſe who have ſeen a lake in a violent ſhower of rain covered all over with bubbles, will conceive ſome idea of its agitations. My ſurprize was ſtill encreaſed by the calmneſs and ſerenity of the weather; not a breeze, not a cloud which might be ſuppoſed to put all Nature thus into motion. I therefore warned my companions that an earthquake was approaching; and, after ſome time, making for the ſhore with all poſſible diligence, we landed at Tropæa, happy and thankful for having eſcaped the threatening dangers of the ſea.

"But our triumphs at land were of ſhort duration; for we had ſcarce arrived at the Jeſuits College in that city, when our ears were ſtunned with an horrid ſound, reſembling that of an infinite number of chariots driven fiercely forward, the wheels rattling, and the thongs cracking. Soon after this, a moſt dreadful earthquake enſued; ſo that the whole tract upon which we ſtood, ſeemed to vibrate, as if we were in the ſcale of a balance that continued wavering. This motion, however, ſoon grew more violent; and being no longer able to keep my legs, I was thrown proſtrate upon the ground. In the mean time, the univerſal ruin round me, redoubled my amazement. The craſh of falling houſes, the tottering of towers, and the groans of the dying, all contributed to raiſe my terror and deſpair. On every ſide of me I ſaw nothing but a ſcene of ruin; and danger threatening wherever I ſhould fly. I commended myſelf to God as my laſt great refuge. At that hour, O how vain was every ſublunary happineſs! wealth, honour, empire, wiſdom, all mere uſeleſs ſounds, and as empty as the bubbles in the deep. Juſt ſtanding on the threſhold of eternity, nothing but God was my pleaſure; and the nearer I approached, I only loved him the more. After ſome time, however, finding that I remained unhurt,

unhurt, amidſt the general concuſſion, I reſolved to venture for ſafety, and running as faſt as I could, reached the ſhore, but almoſt terrified out of my reaſon. I did not ſearch long here till I found the boat in which I had landed, and my companions alſo, whoſe terrors were even greater than mine. Our meeting was not of that kind where every one is deſirous of telling his own happy eſcape; it was all ſilence, and a gloomy dread of impending terrors.

" Leaving this ſeat of deſolation, we proſecuted our voyage along the coaſts; and the next day came to Rochetta, where we landed, although the earth ſtill continued in violent agitations. But we were ſcarce arrived at our inn, when we were once more obliged to return to the boat; and, in about half an hour, we ſaw the greateſt part of the town, and the inn at which we had ſet up, daſhed to the ground, and burying all its inhabitants beneath its ruins.

" In this manner, proceeding onwards in our little veſſel, finding no ſafety at land, and yet, from the ſmallneſs of our boat, having but a very dangerous continuance at ſea, we at length landed at Lopizium, a caſtle midway between Tropæa and Euphemia, the city to which, as I ſaid before, we were bound.

bound. Here, wherever I turned my eyes, nothing but ſcenes of ruin and horror appeared; towns and caſtles levelled to the ground; Strombalo, though at ſixty miles diſtance, belching forth flames in an unuſual manner, and with a noiſe which I could diſtinctly hear. But my attention was quickly turned from more remote to contiguous danger. The rumbling ſound of an approaching earthquake, which we by this time were grown acquainted with, alarmed us for the conſequences; it every moment ſeemed to grow louder, and to approach more near. The place on which we ſtood now began to ſhake moſt dreadfully, ſo that being unable to ſtand, my companions and I caught hold of whatever ſhrub grew next us, and ſupported ourſelves in that manner.

" After ſome time, this violent paroxyſm ceaſing, we again ſtood up, in order to proſecute our voyage to Euphemia, that lay within ſight. In the mean time, while we were preparing for this purpoſe, I turned my eyes towards the city, but could ſee only a frightful dark cloud, that ſeemed to reſt upon the place. This the more ſurprized us, as the weather was very ſerene. We waited, therefore, till the cloud was paſt away: then turning to look for the city, it was totally ſunk. Wonderful to tell! nothing but a diſmal

diſmal and putrid lake was ſeen where it ſtood. We looked about to find ſome one that could tell us of its ſad cataſtrophe, but could ſee none. All was become a melancholy ſolitude; a ſcene of hideous deſolation. Thus proceeding penſively along, in queſt of ſome human being that could give us ſome little information, we at length ſaw a boy ſitting by the ſhore, and appearing ſtupified with terror. Of him, therefore, we enquired concerning the fate of the city; but he could be got to give us no anſwer. We entreated him with every expreſſion of tenderneſs and pity to tell us; but his ſenſes were quite wrapt up in the contemplation of the danger he had eſcaped. We offered him ſome victuals, but he ſeemed to loath the ſight. We ſtill perſiſted in our offices of kindneſs; but he only pointed to the place of the city, like one out of his ſenſes; and then running up into the woods, was never heard of after. Such was the fate of the city of Euphemia: and as we continued our melancholy courſe along the ſhore, the whole coaſt, for the ſpace of two hundred miles, preſented nothing but the remains of cities; and men ſcattered, without an habitation, over the fields. Proceeding thus along, we at length ended our diſtreſſful voyage by arriving at Naples, after having

having eſcaped a thouſand dangers both at ſea and land."

The reader, I hope, will excuſe me for this long tranſlation from a favourite writer, and that the ſooner, as it contains ſome particulars relative to earthquakes not to be found elſewhere. From the whole of theſe accounts we may gather, that the moſt concomitant circumſtances are theſe:

A rumbling ſound before the earthquake. This proceeds from the air, or fire, or both, forcing their way through the chaſms of the earth, and endeavouring to get free, which is alſo heard in volcanoes.

A violent agitation, or heaving of the ſea, ſometimes before and ſometimes after that at land. This agitation is only a ſimilar effect produced on the waters with that at land, and may be called, for the ſake of perſpicuity, a ſea-quake; and this, alſo, is produced by volcanoes.

A ſpouting up of waters to great heights. It is not eaſy to deſcribe the manner in which this is performed; but volcanoes alſo perform the ſame, Veſuvius being known frequently to eject a vaſt body of waters.

A rocking of the earth to and fro, and ſometimes a perpendicular bouncing, if it may

may be ſo called, of the ſame. This difference chiefly ariſes from the ſituation of the place with reſpect to the ſubterranean fire. Directly under, it lifts; at a farther diſtance, it rocks.

Some earthquakes ſeem to travel onward, and are felt in different countries at different hours the ſame day. This ariſes from the great ſhock being given to the earth at one place, and that being communicated onward by an undulatory motion, ſucceſſively affects different regions in its progreſs. As the blow given by a ſtone falling in a lake is not perceived at the ſhores till ſome time after the firſt concuſſion.

The ſhock is ſometimes inſtantaneous, like the exploſion of gunpowder; and ſometimes tremulous, and continuing for ſeveral minutes. The nearer the place where the ſhock is firſt given, the more inſtantaneous and ſimple it appears. At a greater diſtance the earth redoubles the firſt blow with a ſort of vibratory continuation.

As waters have generally ſo great a ſhare in producing earthquakes, it is not to be wondered that they ſhould generally follow thoſe breaches made by the force of fire, and appear in the great chaſms which the earthquake has opened.

Theſe are ſome of the moſt remarkable

phœnomena

phœnomena of earthquakes, preſenting a frightful aſſemblage of the moſt terrible effects of air, earth, fire, and water.

The valley of Solfatara, near Naples, ſeems to exhibit, in a minuter degree, whatever is ſeen of this horrible kind on the great theatre of Nature. This plain, which is about twelve hundred feet long, and a thouſand broad, is emboſomed in mountains, and has in the middle of it a lake of noiſome blackiſh water, covered with a bitumen, that floats upon its ſurface. In every part of this plain, caverns appear ſmoaking with ſulphur, and often emitting flames. The earth, wherever we walk over it, trembles beneath the feet. Noiſes of flames, and the hiſſing of waters, are heard at the bottom. The water ſometimes ſpouts up eight or ten feet high. The moſt noiſome fumes, fœtid water, and ſulphureous vapours, offend the ſmell. A ſtone thrown into any of the caverns, is ejected again with conſiderable violence. Theſe appearances generally prevail when the ſea is any way diſturbed; and the whole ſeems to exhibit the appearance of an earthquake in miniature. However, in this ſmaller ſcene of wonders, as well as in the greater, there are many appearances for which perhaps we ſhall never account; and many queſtions may be aſked, which no con-

conjectures can thoroughly reſolve. It was the fault of the philoſophers of the laſt age, to be more inquiſitive after the cauſes of things, than after the things themſelves. They ſeemed to think that a confeſſion of ignorance cancelled their claims to wiſdom: they, therefore, had a ſolution for every demand. But the preſent age has grown, if not more inquiſitive, at leaſt more modeſt; and none are now aſhamed of that ignorance which labour can neither remedy nor remove.

CHAP. XI.

Of the Appearance of New Iſlands, and Tracts; and of the diſappearing of others.

HITHERTO we have taken a ſurvey only of the evils which are produced by ſubterranean fires, but we have mentioned nothing of the benefits they may poſſibly produce. They may be of uſe in warming and cheriſhing the ground, in promoting vegetation, and giving a more exquiſite flavour to the productions of the earth. The imagination of a perſon who has never been out of our own mild region, can ſcarcely reach to that luxuriant beauty with which all Nature appears cloathed in thoſe very countries that

we

we have but juſt now deſcribed as deſolated by earthquakes, and undermined by ſubterranean fires. It muſt be granted, therefore, that though in thoſe regions they have a greater ſhare in the dangers, they have alſo a larger proportion in the benefits of Nature.

But there is another advantage ariſing from ſubterranean fires, which, though hitherto diſregarded by man, yet may one day become ſerviceable to him; I mean, that while they are found to ſwallow up cities and plains in one place, they are alſo known to produce promontories and iſlands in another. We have many inſtances of iſlands being thus formed in the midſt of the ſea, which though for a long time barren, have afterwards become fruitful ſeats of happineſs and induſtry.

New iſlands are formed in two ways; either ſuddenly, by the action of ſubterraneous fires; or more ſlowly, by the depoſition of mud, carried down by rivers, and ſtopped by ſome accident*. With reſpect particularly to the firſt, ancient hiſtorians, and modern travellers, give us ſuch accounts as we can have no room to doubt of. Seneca aſſures us, that in his time the iſland of Theraſia appeared unexpectedly to ſome mariners, as they were employed in another

* Buffon, vol. ii. p. 343.

purſuit.

purſuit. Pliny aſſures us, that thirteen iſlands in the Mediterranean appeared at once emerging from the water; the cauſe of which he aſcribes rather to the retiring of the ſea in thoſe parts, than to any ſubterraneous elevation. However, he mentions the iſland of Hiera, near that of Theraſia, as formed by ſubterraneous exploſions; and adds to his liſt ſeveral others, formed in the ſame manner. In one of which he relates that fiſh in great abundance were found, and that all thoſe who eat of them died ſhortly after.

" On the twenty-fourth of May †, in the year 1707, a ſlight earthquake was perceived at Santorin; and the day following, at ſun-riſing, an object was ſeen by the inhabitants of that iſland, at two or three miles diſtance at ſea, which appeared like a floating rock. Some perſons, deſirous either of gain, or incited by curioſity, went there, and found, even while they ſtood upon this rock, that it ſeemed to riſe beneath their feet. They perceived alſo, that its ſurface was covered with pumice ſtones, and oyſters, which it had raiſed from the bottom. Every day after, until the fourteenth of June, this rock ſeemed conſiderably to encreaſe; and then was found to be half a mile round, and

† Hiſt. del Accad. an. 1708, p. 23.

about

about thirty feet above the ſea. The earth of which it was compoſed, ſeemed whitiſh, with a ſmall portion of clay. Soon after this the ſea again appeared troubled, and ſteams aroſe, which were very offenſive to the inhabitants of Santorin. But on the ſixteenth of the ſucceeding month, ſeventeen or eighteen rocks more were ſeen to riſe out of the ſea, and at length to join together. All this was accompanied with the moſt terrible noiſe, and fires that proceeded from the iſland that was newly formed. The whole maſs, however, of all this new-formed earth, uniting, encreaſed every day, both in height and breadth, and, by the force of its exploſions, caſt forth rocks to ſeven miles diſtance. This continued to bear the ſame dreadful appearances till the month of November in the ſame year; and it is at preſent a volcano which ſometimes renews its exploſions. It is about three miles in circumference; and more than from thirty-five to forty feet high."

It ſeems extraordinary, that about this place in particular, iſlands have appeared at different times, particularly that of Hiera, mentioned above, which has received conſiderable additions in ſucceeding agee. Juſtin * tells us, that at the time the Macedonians

* Juſtin, l. 30, cap. 4.

were

were at war with the Romans, a new iſland appeared between thoſe of Theramenes and Theraſia, by means of an earthquake. We are told, that this became half as big again about a thouſand years after; another iſland riſing up by its ſide, and joining to it, ſo as ſcarce at preſent to be diſtinguiſhed from the former.

A new iſland was formed, in the year 1720, near that of Tercera, near the continent of Africa, by the ſame cauſes. In the beginning of December, at night, there was a terrible earthquake at that place, and the top of a new iſland appeared, which caſt forth ſmoke in vaſt quantities. The pilot of a ſhip, who approached it, ſounded on one ſide of this iſland, and could not find ground at ſixty fathom. At the other ſide the ſea was totally tinged of a different colour, exhibiting a mixture of white, blue, and green; and was very ſhallow. This iſland, on its firſt appearance, was larger than it is at preſent; for it has, ſince that time, ſunk in ſuch a manner, as to be ſcarce above water.

A traveller, whom theſe appearances could not avoid affecting, ſpeaks of them in this manner: * "What can be more ſurprizing than to ſee fire not only break out of the bowels of the earth, but alſo to make itſelf a paſ-

* Phil. Tranſ. vol. v, p. 197.

ſage

ſage through the waters of the ſea! What can be more extraordinary or foreign to our common notions of things, than to ſee the bottom of the ſea riſe up into a mountain above the water, and become ſo firm an iſland as to be able to reſiſt the violence of the greateſt ſtorms! I know that ſubterraneous fires, when pent in a narrow paſſage, are able to raiſe up a maſs of earth as large as an iſland. But that this ſhould be done in ſo regular and exact a manner, that the water of the ſea ſhould not be able to penetrate and extinguiſh thoſe fires; that, after having made ſo many paſſages, they ſhould retain force enough to raiſe the earth; and, in fine, after having been extinguiſhed, that the maſs of earth ſhould not fall down, or ſink again with its own weight, but ſtill remain in a manner ſuſpended over the great arch below! This is what to me ſeems more ſurprizing than any thing that has been related of Mount Ætna, Veſuvius, or any other volcano."

Such are his ſentiments; however, there are few of theſe appearances any way more extraordinary than thoſe attending volcanoes and earthquakes in general. We are not more to be ſurprized that inflammable ſubſtances ſhould be found beneath the bottom of the ſea, than at ſimilar depths at land.

Theſe have all the force of fire giving expanſion to air, and tending to raiſe the earth at the bottom of the ſea, till it at length heaves above water. Theſe marine volcanoes are not ſo frequent; for, if we may judge of the uſual procedure of Nature, it muſt very often happen that, before the bottom of the ſea is elevated above the ſurface, a chaſm is opened in it, and then the water preſſing in, extinguiſhes the volcano before it has time to produce its effects. This extinction, however, is not effected without very great reſiſtance from the fire beneath. The water, upon daſhing into the cavern, is very probably at firſt ejected back with great violence; and thus ſome of thoſe amazing water-ſpouts are ſeen, which have ſo often aſtoniſhed the mariner, and excited curioſity.---But of theſe in their place.

Beſides the production of thoſe iſlands by the action of fire, there are others, as was ſaid, produced by rivers or ſeas carrying mud, earth, and ſuch like ſubſtances, along with their currents; and at laſt depoſiting them in ſome particular place. At the mouths of moſt great rivers, there are to be ſeen banks, thus formed by the ſand and mud carried down with the ſtream, which have reſted at that place, where the force of the current is diminiſhed by its junction with the ſea. Theſe banks, by ſlow degrees,

grees, encreaſe at the bottom of the deep; the water, in thoſe places, is at firſt found by mariners to grow more ſhallow; the bank ſoon heaves up above the ſurface; it is conſidered, for a while, as a tract of uſeleſs and barren ſand; but the ſeeds of ſome of the more hardy vegetables are driven thither by the wind, they take root, and thus binding the ſandy ſurface, the whole ſpot is cloathed in time with a beautiful verdure. In this manner there are delightful and inhabited iſlands at the mouths of many rivers, particularly the Nile, the Po, the Miſſiſippi, the Ganges, and the Senegal. There has been, in the memory of man, a beautiful and large iſland formed in this manner, at the mouth of the river Nanquin, in China, made from depoſitions of mud at its opening: it is not leſs than ſixty miles long, and about twenty broad. La Loubere informs us*, in his voyage to Siam, that theſe ſand-banks encreaſe every day, at the mouths of all the great rivers in Aſia: and hence he aſſerts, that the navigation up theſe rivers becomes every day more difficult; and will, at one time or another, be totally obſtructed. The ſame may be remarked with regard to the Wolga, which has at preſent ſeventy openings into the

* Lettres Curieuſes et Edificantes, ſect. xi, p. 234.

Caſpian ſea; and of the Danube, which has ſeven into the Euxine. We have had an inſtance of the formation of a new iſland, not very long ſince, at the mouth of the Humber, in England. "It is yet within the memory of man," ſays the relator*, "ſince it began to raiſe its head above the ocean. It began its appearance at low water, for the ſpace of a few hours; and was buried again till the next tide's retreat. Thus, ſucceſſively, it lived and died, until the year 1666, when it began to maintain its ground againſt the inſult of the waves; and then firſt invited the aid of human induſtry. A bank was thrown about its riſing grounds; and being thus defended from the incurſions of the ſea, it became firm and ſolid, and, in a ſhort time, afforded good paſturage for cattle. It is about nine miles in circumference, and is worth to the proprietor about eight hundred pounds a year." It would be endleſs to mention all the iſlands that have been thus formed; and the advantages that have been derived from them. However, it is frequently found, that new iſlands thus formed, may often be conſidered as only turning the rivers from their former beds; ſo that, in proportion as land is gained at one part, it is loſt by the overflowing of ſome other.

* Phil. Tranſ. vol. iv. p. 251.

Little,

Little, therefore, is gained by ſuch acceſſions. Nor is there much more by the new iſlands which are ſometimes formed from the ſpoils of the continent. Mariners aſſure us, that there are ſometimes whole plains unrooted from the main lands, by floods and tempeſts. Theſe being carried out to ſea, with all their trees and animals upon them, are frequently ſeen floating in the ocean, and exhibiting a ſurprizing appearance of rural tranquillity in the midſt of danger, The greateſt part, however, having the earth at their roots at length waſhed away, are diſperſed, and their animals drowned; but now and then ſome are found to brave the fury of the ocean, till being ſtuck either among rocks or ſands, they again take firm footing, and become permanent iſlands.

As different cauſes have thus concurred to produce new iſlands, ſo we have accounts of others that the ſame cauſes have contributed to deſtroy. We have already ſeen the power of earthquakes exerted in ſinking whole cities, and leaving lakes in their room. There have been iſlands, and regions alſo, that have ſhared the ſame fate; and have ſunk with their inhabitants, never more to be heard of. Thus Pauſanias * tells us of an iſland,

* Pauſanias, l. 8, in Arcad. p. 509.

called

called Chryſes, that was ſunk near Lemnos. Pliny mentions ſeveral; among others, the iſland Cea, for thirty miles, having been waſhed away, with ſeveral thouſands of its inhabitants. But of all the noted devaſtations of this kind, the total ſubmerſion of the iſland of Atalantis, as mentioned by Plato, has been moſt the ſubject of ſpeculation. Mankind, in general, now conſider the whole of his account as an ingenious fable; but when fables are grown famous by time and authority, they become an agreeable, if not a neceſſary part of literary information.

About nine thouſand years are paſſed, ſays Plato*, ſince the iſland of Atalantis was in being. The prieſts of Egypt were well acquainted with it; and the firſt heroes of Athens gained much glory in their wars with the inhabitants. This iſland was as large as Aſia Minor and Syria united; and was ſituated beyond the pillars of Hercules, in the Atlantic ocean. The beauty of the buildings, and the fertility of the ſoil, were far beyond any thing a modern imagination can conceive; gold and ivory were every where common; and the fruits of the earth offered themſelves without cultivation. The arts, and the courage of the inhabitants, were not inferior to the happineſs of their

* Plato in Critia.

ſitu-

ſituation; and they were frequently known to make conqueſts, and overrun the continent of Europe and Aſia. The imagination of the poetical philoſopher riots in the deſcription of the natural and acquired advantages, which they long enjoyed in this charming region. If, ſays he, we compare that country to our own, ours will appear a mere waſted ſkeleton, when oppoſed to it. Their mountains to the very tops were cloathed with fertility, and poured down rivers to enrich the plains below.

However, all theſe beauties and benefits were deſtroyed in one day by an earthquake ſinking the earth, and the ſea overwhelming it. At preſent, not the ſmalleſt veſtiges of ſuch an iſland are to be found; Plato remains as the only authority for its exiſtence; and philoſophers diſpute about its ſituation. It is not for me to enter into the controverſy, when there appears but little probability to ſupport the fact; and, indeed, it would be uſeleſs to run back nine thouſand years in ſearch of difficulties, as we are ſurrounded with objects that more cloſely affect us, and that demand admiration at our very doors. When I conſider, as Lactantius ſuggeſts, the various viciſſitudes of nature; lands ſwallowed by yawning earthquakes, or overwhelmed in the deep; rivers and lakes diſappearing,

appearing, or dried away; mountains levelled into plans; and plains ſwelling up into mountains; I cannot help regarding this earth as a place of very little ſtability; as a tranſient abode of ſtill more tranſitory beings.

CHAP. XII.

Of Mountains.

HAVING at laſt, in ſome meaſure, emerged from the deeps of the earth, we come to a ſcene of greater ſplendor; the contemplation of its external appearance. In this ſurvey, its mountains are the firſt objects that ſtrike the imagination, and excite our curioſity. There is not, perhaps, any thing in all nature that impreſſes an unaccuſtomed ſpectator with ſuch ideas of awful ſolemnity, as theſe immenſe piles of Nature's erecting, that ſeem to mock the minuteneſs of human magnificence.

In countries where there are nothing but plains, the ſmalleſt elevations are apt to excite wonder. In Holland, which is all a flat, they ſhew a little ridge of hills, near the ſea-ſide, which Boerhaave generally marked out to his pupils as being mountains of no ſmall con-

conſideration. What would be the ſenſations of ſuch an auditory, could they at once be preſented with a view of the heights and precipices of the Alps, or the Andes! Even among us in England, we have no adequate ideas of a mountain-proſpect; our hills are generally ſloping from the plain, and cloathed to the very top with verdure; we can ſcarce, therefore, lift our imaginations to thoſe immenſe piles whoſe tops peep up behind intervening clouds, ſharp and precipitate, and reach to heights that human avarice or curioſity have never been able to aſcend.

We, in this part of the world, are not, for that reaſon, ſo immediately intereſted in the queſtion which has ſo long been agitated among philoſophers, concerning what gave riſe to theſe inequalities on the ſurface of the globe. In our own happy region, we generally ſee no inequalities but ſuch as contribute to uſe and beauty; and we, therefore, are amazed at a queſtion enquiring how ſuch neceſſary inequalities came to be formed, and ſeeming to expreſs a wonder how the globe comes to be ſo beautiful as we find it. But though with us there may be no great cauſe for ſuch a demand, yet in thoſe places where mountains deform the face of Nature, where they pour down cataracts, or give fury

to

to tempeſts, there ſeems to be good reaſon for enquiry into their cauſes or their uſes. It has been, therefore, aſked by many, in what manner mountains have come to be formed; or for what uſes they are deſigned?

To ſatisfy curioſity in theſe reſpects, much reaſoning has been employed, and very little knowledge propagated. With regard to the firſt part of the demand, the manner in which mountains were formed, we have already ſeen the conjectures of different philoſophers on that head. One ſuppoſing that they were formed from the earth's broken ſhell, at the time of the deluge: another, that they exiſted from the creation, and only acquired their deformities in proceſs of time: a third, that they owed their original to earthquakes: and ſtill a fourth, with much more plauſibility than the reſt, aſcribing them entirely to the fluctuations of the deep, which he ſuppoſes in the beginning to have covered the whole earth. Such as are pleaſed with diſquiſitions of this kind, may conſult Burnet, Whiſton, Woodward, or Buffon. Nor would I be thought to decry any mental amuſements, that at worſt keep us innocently employed; but, for my own part, I cannot help wondering how the oppoſite demand has never come to be made; and why philoſophers

loſophers have never aſked how we come to have plains? Plains are ſometimes more prejudicial to man than mountains. Upon plains, an inundation has greater power; the beams of the ſun are often collected there with ſuffocating fierceneſs; they are ſometimes found deſert for ſeveral hundred miles together, as in the country eaſt of the Caſpian ſea, although otherwiſe fruitful, merely becauſe there are no riſings nor depreſſions to form reſervoirs, or collect the ſmalleſt rivulet of water. The moſt rational anſwer, therefore, why either mountains or plains were formed, ſeems to be, that they were thus faſhioned by the hand of Wiſdom, in order that pain and pleaſure ſhould be ſo contiguous as that morality might be exerciſed either in bearing the one, or communicating the other.

Indeed, the more I conſider this diſpute reſpecting the formation of mountains, the more I am ſtruck with the futility of the queſtion. There is neither a ſtrait line, nor an exact ſuperficies, in all nature. If we conſider a circle, even with mathematical preciſion, we ſhall find it formed of a number of ſmall right lines, joining at angles together. Theſe angles, therefore, may be conſidered in a circle as mountains are upon our globe; and to demand the reaſon for

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the one being mountainous, or the other angular, is only to aſk why a circle is a circle, or a globe is a globe. In ſhort, if there be no ſurface without inequality in Nature, why ſhould we be ſurprized that the earth has ſuch? It has often been ſaid, that the inequalities of its ſurface are ſcarce diſtinguiſhable, if compared to its magnitude; and I think we have every reaſon to be content with the anſwer.

Some, however, have avoided the difficulty by urging the final cauſe. They alledge that mountains have been formed merely becauſe they are uſeful to man. This carries the enquirer but a part of the way; for no one can affirm that in all places they are uſeful. The contrary is known, by horrid experience, in thoſe valleys that are ſubject to their influence. However, as the utility of any part of our earthly habitation, is a very pleaſing and flattering ſpeculation to every philoſopher, it is not to be wondered that much has been ſaid to prove the uſefulneſs of theſe. For this purpoſe, many conjectures have been made that have received a degree of aſſent even beyond their evidence; for men were unwilling to become more miſerably wiſe.

It has been alledged, as one principal advantage that we derive from them, that they

ſerve,

ſerve, like hoops or ribs, to ſtrengthen our earth, and to bind it together. In conſequence of this theory, Kircher has given us a map of the earth, in this manner hooped with its mountains; which might have a much more ſolid foundation, did it entirely correſpond with truth.

Others have found a different uſe for them, eſpecially when they run ſurrounding our globe; which is, that they ſtop the vapours that are continually travelling from the equator to the poles; for theſe being urged by the heat of the ſun, from the warm regions of the line, muſt all be accumulated at the poles, if they were not ſtopped in their way by thoſe high ridges of mountains which croſs their direction. But an anſwer to this may be, that all the great mountains in America lie lengthwiſe, and therefore do not croſs their direction.

But to leave theſe remote advantages, others aſſert, that not only the animal but vegetable part of creation would periſh for want of convenient humidity, were it not for their friendly aſſiſtance. Their ſummits are, by theſe, ſuppoſed to arreſt, as it were, the vapours which float in the regions of the air. Their large inflexions, and channels, are conſidered as ſo many baſons prepared

pared for the reception of thoſe thick vapours, and impetuous rains, which deſcend into them. The huge caverns beneath are ſo many magazines or conſervatories of water for the peculiar ſervice of man: and thoſe orifices by which the water is diſcharged upon the plain, are ſo ſituated as to enrich and render them fruitful, inſtead of returning through ſubterraneous channels to the ſea, after the performance of a tedious and fruitleſs circulation *.

However this be, certain it is that almoſt all our great rivers find their ſource among mountains; and, in general, the more extenſive the mountain, the greater the river: thus the river Amazons, the greateſt in the world, has its ſource among the Andes, which are the higheſt mountains on the globe; the river Niger travels a long courſe of ſeveral hundred miles from the mountains of the Moon, the higheſt in all Africa; and the Danube and the Rhine proceed from the Alps, which are probably the higheſt mountains of Europe.

It need ſcarce be ſaid that, with reſpect to height, there are many ſizes of mountains, from the gently riſing upland, to the tall

* Nature Diſplay'd, vol. iii. p. 88.

craggy

craggy precipice. The appearance is in general different in thoſe of different magnitudes. The firſt are cloathed with verdure to the very tops, and only ſeem to aſcend to improve our proſpects, or ſupply us with a purer air: but the lofty mountains of the other claſs have a very different aſpect. At a diſtance their tops are ſeen, in wavy ridges, of the very colour of the clouds, and only to be diſtinguiſhed from them by their figure, which, as I have ſaid, reſembles the billows of the ſea *. As we approach, the mountain aſſumes a deeper colour; it gathers upon the ſky, and ſeems to hide half the horizon behind it. Its ſummits alſo are become more diſtinct, and appear with a broken and perpendicular line. What at firſt ſeemed a ſingle hill, is now found to be a chain of continued mountains, whoſe tops running along in ridges, are emboſomed in each other; ſo that the curvatures of one are fitted to the prominences of the oppoſite ſide, and form a winding valley between, often of ſeveral miles in extent; and all the way continuing nearly of the ſame breadth. Nothing can be finer, or more exact than Mr. Pope's deſcription of a traveller ſtraining up the Alps. Every mountain he comes to he thinks will

* Lettres Philoſophiques ſur la Formation, &c. p. 196.

be

be the laſt; he finds, however, an unexpected hill riſe before him; and that being ſcaled, he finds the higheſt ſummit almoſt at as great a diſtance as before. Upon quitting the plain, he might have left a green and a fertile ſoil, and a climate warm and pleaſing. As he aſcends, the ground aſſumes a more ruſſet colour; the graſs becomes more moſſy; and the weather more moderate. Still as he aſcends, the weather becomes more cold, and the earth more barren. In this dreary paſſage, he is often entertained with a little valley of ſurprizing verdure, cauſed by the reflected heat of the ſun collected into a narrow ſpot on the ſurrounding heights. But it much more frequently happens that he ſees only frightful precipices beneath, and lakes of amazing depths; from whence rivers are formed, and fountains derive their original. On thoſe places next the higheſt ſummits, vegetation is ſcarcely carried on; here and there a few plants of the moſt hardy kind appear. The air is intolerably cold; either continually refrigerated with froſts, or diſturbed with tempeſts. All the ground here wears an eternal covering of ice, and ſnows that ſeem conſtantly accumulating. Upon emerging from this war of the elements, he aſcends into a purer and a ſerener region, where vegetation is entirely ceaſed;

ceaſed; where the precipices, compoſed entirely of rocks, riſe perpendicularly above him; while he views beneath him all the combat of the elements; clouds at his feet; and thunders darting upward from their boſoms below *. A thouſand meteors, which are never ſeen on the plain, preſent themſelves. Circular rainbows †; mock ſuns; the ſhadow of the mountain projected upon the body of the air ‡; and the traveller's own image, reflected as in a looking-glaſs, upon the oppoſite cloud ||.

Such are, in general, the wonders that preſent themſelves to a traveller in his journey either over the Alps or the Andes. But we muſt not ſuppoſe that this picture exhibits either a conſtant or an invariable likeneſs of thoſe ſtupendous heights. Indeed, nothing can be more capricious or irregular than the forms of many of them. The tops of ſome run in ridges for a conſiderable length, without interruption; in others, the line ſeems notched by great vallies to an amazing depth. Sometimes a ſolitary and a ſingle mountain riſes from the boſom of the plain; and ſometimes extenſive plains, and even provinces, as thoſe of Savoy and Quito, are found emboſomed near the tops of moun-

* Ulloa, vol. i. † Ibid. ‡ Phil. Tranſ. vol. v. p. 152. || Ulloa, vol. i.

tains. In general, however, thoſe countries that are moſt mountainous, are the moſt barren and uninhabitable.

If we compare the heights of mountains with each other, we ſhall find that the greateſt and higheſt are found under the Line *. It is thought by ſome, that the rapidity of the earth's motion in theſe parts, together with the greatneſs of the tides there, may have thrown up thoſe ſtupendous maſſes of earth. But, be the cauſe as it may, it is a remarkable fact, that the inequalities of the earth's ſurface are greateſt there. Near the Poles, the earth, indeed, is craggy and uneven enough; but the heights of the mountains there, are very inconſiderable. On the contrary, at the Equator, where Nature ſeems to ſport in the amazing ſize of all her productions, the plains are extenſive; and the mountains remarkably lofty. Some of them are known to riſe three miles perpendicular above the bed of the ocean.

To enumerate the moſt remarkable of theſe, according to their ſize, we ſhall begin with the Andes, of which we have an excellent deſcription by Ulloa, who went thither by command of the king of Spain, in company with the French Academicians, to meaſure a degree of the meridian. His journey

* Buffon. Paſſim.

up

up theſe mountains is too curious not to give an extract from it.

After many incommodious days ſailing up the river Guayaquil, he arrived at Caracol, a town ſituated at the foot of the Andes. Nothing could exceed the inconveniencies which he experienced in this voyage, from the flies and moſchitoes (an animal reſembling our gnat). "We were the whole day," ſays he, "in continual motion to keep them off; but at night our torments were exceſſive. Our gloves, indeed, were ſome defence to our hands; but our faces were entirely expoſed; nor were our cloaths a ſufficient defence for the reſt of our bodies; for their ſtings penetrating through the cloth, cauſed a very painful and fiery itching. One night, in coming to an anchor near a large and handſome houſe that was uninhabited, we had no ſooner ſeated ourſelves in it, than we were attacked on all ſides by ſwarms of moſchitoes, ſo that it was impoſſible to have one moment's quiet. Thoſe who had covered themſelves with cloaths made for this purpoſe, found not the ſmalleſt defence; wherefore, hoping to find ſome relief in the open fields, they ventured out, though in danger of ſuffering in a more terrible manner from the ſerpents. But both places were equally obnoxious. On quitting this in-

hoſpitable retreat, we the next night took up our quarters in an houſe that was inhabited; the hoſt of which being informed of the terrible manner we had paſt the night before, he gravely told us, that the houſe we ſo greatly complained of, had been forſaken on account of its being the purgatory of a ſoul. But we had more reaſon to believe that it was quitted on account of its being the purgatory of the body. After having journeyed for upwards of three days, through boggy roads, in which the mules at every ſtep ſunk up to their bellies, we began at length to perceive an alteration in the climate; and having been long accuſtomed to heat, we now began to feel it grown ſenſibly colder.

" It is remarkable, that at Tariguagua we often ſee inſtances of the effects of two oppoſite temperatures, in two perſons happening to meet; one of them leaving the plains below, and the other deſcending from the mountain. The former thinks the cold ſo ſevere, that he wraps himſelf up in all the garments he can procure; while the latter, finds the heat ſo great, that he is ſcarce able to bear any cloaths whatſoever. The one thinks the water ſo cold, that he avoids being ſprinkled by it; the other is ſo delighted with its warmth, that he uſes it as a bath.

bath. Nor is the caſe very different in the ſame perſon, who experiences the ſame diverſity of ſenſation upon his journey up, and upon his return. This difference only proceeds from the change naturally felt at leaving a climate to which one has been accuſtomed, and coming into another of an oppoſite temperature.

" The ruggedneſs of the road from Tariguagua, leading up the mountain, is not eaſily deſcribed. In ſome parts, the declivity is ſo great, that the mules can ſcarce keep their footing; and in others, the acclivity is equally difficult. The trouble of having people going before to mend the road, the pains ariſing from the many falls and bruiſes, and the being conſtantly wet to the ſkin, might be ſupported, were not theſe inconveniences augmented by the ſight of ſuch frightful precipices, and deep abyſſes, as muſt fill the mind with ceaſeleſs terror. There are ſome places where the road is ſo ſteep, and yet ſo narrow, that the mules are obliged to ſlide down, without making any uſe of their feet whatſoever. On one ſide of the rider, in this ſituation, riſes an eminence of ſeveral hundred yards; and on the other, an abyſs of equal depth; ſo that if he in the leaſt checks his mule, ſo as to deſtroy the equilibrium, they both muſt unavoidably periſh.

" After

" After having travelled about nine days in this manner, ſlowly winding along the ſide of the mountain, we began to find the whole country covered with an hoar froſt; and an hut, in which we lay, had ice on it. Having eſcaped many perils, we at length, after a journey of fifteen days, arrived upon the plain, on the extremity of which ſtands the city of Quito, the capital of one of the moſt charming regions upon earth. Here, in the center of the torrid zone, the heat is not only very tolerable, but in ſome places the cold alſo is painful. Here they enjoy all the temperature and advantages of perpetual ſpring; their fields being always covered with verdure, and enamelled with flowers of the moſt lively colours. However, although this beautiful region be higher than any other country in the world, and although it took up ſo many days of painful journey in the aſcent, it is ſtill overlooked by tremendous mountains; their ſides covered with ſnow, and yet flaming with volcanoes at the top. Theſe ſeem piled one upon the other, and riſe to a moſt aſtoniſhing height, with great coldneſs. However, at a determined point above the ſurface of the ſea, the congelation is found at the ſame height in all the mountains. Thoſe parts which are not ſubject to a continual froſt, have here and

there

there growing upon them a ruſh, reſembling the geniſta, but much more ſoft and flexible. Towards the extremity of the part where the ruſh grows, and the cold begins to encreaſe, is found a vegetable, with a round bulbous head, which, when dried, becomes of amazing elaſticity. Higher up the earth is entirely bare of vegetation, and ſeems covered with eternal ſnow. The moſt remarkable mountains are, that of Cotopaxi, (already deſcribed as a volcano) Chimborazo, and Pichincha. Cotopaxi is more than three geographical miles above the ſurface of the ſea: the reſt are not much inferior. On the top of the latter was my ſtation for meaſuring a degree of the meridian; where I ſuffered particular hardſhips, from the intenſeneſs of the cold, and the violence of the ſtorms. The ſky around was, in general, involved in thick fogs, which, when they cleared away, and the clouds, by their gravity, moved nearer to the ſurface of the earth, they appeared ſurrounding the foot of the mountain, at a vaſt diſtance below, like a ſea, encompaſſing an iſland in the midſt of it. When this happened, the horrid noiſes of tempeſts were heard from beneath, then diſcharging themſelves on Quito, and the neighbouring country. I ſaw the lightenings

ings iſſue from the clouds, and heard the thunders roll far beneath me. All this time, while the tempeſt was raging below, the mountain top, where I was placed, enjoyed a delightful ſerenity; the wind was abated; the ſky clear; and the enlivening rays of the ſun moderated the ſeverity of the cold. However, this was of no very long duration, for the wind returned with all its violence, and with ſuch velocity as to dazzle the ſight; whilſt my fears were encreaſed by the dreadful concuſſions of the precipice, and the fall of enormous rocks; the only ſounds that were heard in this frightful ſituation."

Such is the animated picture of theſe mountains, as given us by this ingenious Spaniard: and I believe the reader will wiſh that I had made the quotation ſtill longer. A paſſage over the Alps, or a journey acroſs the Pyrenees, appear pretty trips or excurſions, in the compariſon; and yet theſe are the moſt lofty mountains we know of in Europe.

If we compare the Alps with the mountains already deſcribed, we ſhall find them but little more than one half of the height of the former. The Andes, upon being meaſured by the barometer are found above three thouſand, one hundred and thirty-ſix

toiſes

toiſes or fathoms above the ſurface of the ſea *. Whereas the higheſt point of the Alps is not above ſixteen hundred. The one, in other words, is above three miles high; the other, about a mile and a half. The higheſt mountains of Aſia are, Mount Taurus, Mount Immaus, Mount Caucaſus, and the mountains of Japan.---Of theſe, none equals the Andes in height; although Mount Caucaſus, which is the higheſt of them, makes very near approaches. Father Verbieſt tells of a mountain in China, which he meaſured, and found a mile and a half high †. In Africa, the mountains of the Moon, famous for giving ſource to the Niger, and the Nile, are rather more noted than known. Of the Pike of Teneriffe, one of the Canary Iſlands that lie off this coaſt, we have more certain information. In the year 1727, it was viſited by a company of Engliſh merchants, who travelled up to the top, where they obſerved its height, and the volcano on its very ſummit ‡. They found it an heap of mountains, the higheſt of which riſes over the reſt like a ſugar-loaf, and gives a name to the whole maſs. It is computed to be a mile and an half perpendicular from the ſurface of the ſea. Kircher

* Ulloa, vol. i. p. 442. † Verbieſt, alla Chine.
‡ Phil. Tranſ. vol. v.

gives

gives us an eſtimate of the heights of moſt of the other great mountains in the world; but as he has taken his calculations, in general, from the ancients, or from modern travellers, who had not the art of meaſuring them, they are quite incredible. The art of taking the heights of places by the barometer, is a new, and an ingenious invention. As the air grows lighter as we aſcend, the fluid in the tube riſes in due proportion: thus the inſtrument being properly marked, gives the height with a tolerable degree of exactneſs; at leaſt enough to ſatisfy curioſity.

Few of our great mountains have been eſtimated in this manner; travellers having, perhaps, been deterred, by a ſuppoſed impoſſibility of breathing at the top. However, it has been invariably found, that the air in the higheſt that our modern travellers have aſcended, is not at all too fine for reſpiration. At the top of the Pike of Teneriff, there was found no other inconvenience from the air, except its coldneſs; at the top of the Andes, there was no difficulty of breathing perceived. The accounts, therefore, of thoſe who have aſſerted that they were unable to breathe, although at much leſs heights, are greatly to be ſuſpected. In fact, it is very natural for mankind to paint thoſe obſtacles as

inſur-

inſurmountable, which they themſelves have not had the fortitude or perſeverance to ſurmount.

The difficulty and danger of aſcending to the tops of mountains, proceeds from other cauſes, not the thinneſs of the air. For inſtance, ſome of the ſummits of the Alps have never yet been viſited by man. But the reaſon is, that they riſe with ſuch a rugged and precipitate aſcent, that they are utterly inacceſſible. In ſome places they appear like a great wall of ſix or ſeven hundred feet high; in others, there ſtick out enormous rocks, that hang upon the brow of the ſteep, and every moment threaten deſtruction to the traveller below.

In this manner almoſt all the tops of the higheſt mountains are bare and pointed. And this naturally proceeds from their being ſo continually aſſaulted by thunders and tempeſts. All the earthy ſubſtances with which they might have been once covered, have for ages been waſhed away from their ſummits; and nothing is left remaining, but immenſe rocks, which no tempeſt has hitherto been able to deſtroy.

Nevertheleſs, time is every day, and every hour, making depredations; and huge fragments are ſeen tumbling down the precipice, either looſened from the ſummit by froſt or rains,

rains, or ſtruck down by lightening. Nothing can exhibit a more terrible picture than one of theſe enormous rocks, commonly larger than an houſe, falling from its height, with a noiſe louder than thunder, and rolling down the ſide of the mountain. Doctor Plot tells us of one in particular, which being looſened from its bed, tumbled down the precipice, and was partly ſhattered into a thouſand pieces. Notwithſtanding, one of the largeſt fragments of the ſame, ſtill preſerving its motion, travelled over the plain below, croſſed a rivulet in the midſt, and at laſt ſtopped on the other ſide of the bank! Theſe fragments, as was ſaid, are often ſtruck off by lightening, and ſometimes undermined by rains; but the moſt uſual manner in which they are diſunited from the mountain, is by froſt: the rains inſinuating between the interſtices of the mountain, continue there until there comes a froſt, and then, when converted into ice, the water ſwells with an irreſiſtible force, and produces the ſame effect as gun-powder, ſplitting the moſt ſolid rocks, and thus ſhattering the ſummits of the mountain.

But not rocks alone, but whole mountains are, by various cauſes, diſunited from each other. We ſee, in many parts of the Alps,

amazing

amazing clefts, the ſides of which ſo exactly correſpond with the oppoſite, that no doubt can be made of their having been once joined together. At Cajeta *, in Italy, a mountain was ſplit in this manner by an earthquake; and there is a paſſage opened through it, that appears as if elaborately done by the induſtry of man. In the Andes theſe breaches are frequently ſeen. That at Thermopyle, in Greece, has been long famous. The mountain of the Troglodytes, in Arabia, has thus a paſſage through it: and that in Savoy, which Nature began, and which Victor Amadeus completed, is an inſtance of the ſame kind.

We have accounts of ſome of theſe diſruptions, immediately after their happening. "In the month of June †, in the year 1714, a part of the mountain of Diableret, in the diſtrict of Valais, in France, ſuddenly fell down, between two and three o'clock in the afternoon, the weather being very calm and ſerene. It was of a conical figure, and deſtroyed fifty-five cottages in the fall. Fifteen perſons, together with about an hundred beaſts, were alſo cruſhed beneath its ruins, which covered an extent of a good league ſquare. The duſt it occaſioned, inſtantly

* Buffon, vol. ii. p. 364.

† Hiſt. de l' Academie des Sciences, p. 4, an. 1715.

covered

covered all the neighbourhood in darkneſs. The heaps of rubbiſh were more than three hundred feet high. They ſtopped the current of a river that ran along the plain, which now is formed into ſeveral new and deep lakes. There appeared, through the whole of this rubbiſh, none of thoſe ſubſtances that ſeemed to indicate that this diſruption had been made by means of ſubterraneous fires. Moſt probably, the baſe of this rocky mountain was rotted and decayed; and thus fell, without any extraneous violence." In the ſame manner, in the year 1618, the town of Pleurs, in France, was buried beneath a rocky mountain, at the foot of which it was ſituated.

Theſe accidents, and many more that might be enumerated of the ſame kind, have been produced by various cauſes: by earthquakes, as in the mountain at Cajeta; or by being decayed at the bottom, as at Diableret. But the moſt general way is, by the foundation of one part of the mountain being hollowed by waters, and, thus wanting a ſupport, breaking from the other. Thus it generally has been found in the great chaſms in the Alps; and thus it almoſt always is known in thoſe diſruptions of hills, which are known by the name of land-ſlips. Theſe are nothing more than the ſliding down of an higher piece of ground, diſrooted from its

ſituation

ſituation by ſubterraneous inundations, and ſettling itſelf upon the plain below.

There is not an appearance in all nature that ſo much aſtoniſhed our anceſtors, as theſe land-ſlips. In fact, to behold a large upland, with its houſes, its corn, and cattle, at once looſened from its place, and floating, as it were, upon the ſubjacent water; to behold it quitting its ancient ſituation, and travelling forward like a ſhip, in queſt of new adventures; this is certainly one of the moſt extraordinary appearances that can be imagined; and to a people, ignorant of the powers of Nature, might well be conſidered as a prodigy. Accordingly, we find all our old hiſtorians mentioning it as an omen of approaching calamities. In this more enlightened age, however, its cauſe is very well known; and, inſtead of exciting ominous apprehenſions in the populace, it only gives riſe to ſome very ridiculous law-ſuits among them, about whoſe the property ſhall be; whether the land which has thus ſlipt, ſhall belong to the original poſſeſſor, or to him upon whoſe grounds it has encroached and ſettled. What has been the determination of the judges, is not ſo well known; but the circumſtances of the ſlips themſelves have been minutely enough, and exactly deſcribed.

In

In the lands of Slatberg*, in the kingdom of Iceland, there ſtood a declivity, gradually aſcending for near half a mile. In the year 1713, and on the 10th of March, the inhabitants perceived a crack on its ſide, ſomewhat like a furrow made with a plough, which they imputed to the effects of lightening, as there had been thunder the night before. However, on the evening of the ſame day, they were ſurprized to hear an hideous confuſed noiſe iſſuing all round from the ſide of the hill; and their curioſity being raiſed, they reſorted to the place. There, to their amazement, they found the earth, for near five acres, all in gentle motion, and ſliding down the hill upon the ſubjacent plain. This motion continued the remaining part of the day, and the whole night; nor did the noiſe ceaſe during the whole time; proceeding, probably, from the attrition of the ground beneath. The day following, however, this ſtrange journey down the hill ceaſed entirely; and above an acre of the meadow below, was found covered with what before compoſed a part of the declivity.

However, theſe ſlips, when a whole mountain's ſide ſeems to deſcend, happen but very rarely. There are ſome of another kind,

* Phil. Tranſ. vol. iv. p. 250.

ever,

ever, much more common; and, as they are always ſudden, much more dangereus. Theſe are ſnow-ſlips, well known, and greatly dreaded by travellers. It often happens, that when ſnow has long been accumulated on the tops and on the ſides of mountains, it is borne down the precipice, either by means of tempeſts, or its own melting. At firſt, when looſened, the volume in motion is but ſmall; but it gathers as it continues to roll; and, by the time it has reached the habitable parts of the mountain, it is generally grown of enormous bulk. Wherever it rolls, it levels all things in its way; or buries them in unavoidable deſtruction. Inſtead of rolling, it ſometimes is found to ſlide along from the top; yet even thus it is generally as fatal as before. Nevertheleſs, we have had an inſtance, a few years ago, of a ſmall family in Germany, that lived for above a fortnight beneath one of theſe ſnow-ſlips. Although they were buried, during that whole time, in utter darkneſs, and under a bed of ſome hundred feet deep, yet they were luckily taken out alive; the weight of the ſnow being ſupported by a beam that kept up the roof; and nouriſhment being ſupplied them by the milk of a goat, if I remember right, that was buried under the ſame ruin.

But it is not the parts, alone, that are thus found to ſubſide, whole mountains have been known totally to diſappear. Pliny * tells us, that in his own time, the lofty mountain of Cybotus, together with the city of Eurites, were ſwallowed by an earthquake. The ſame fate, he ſays, attended Phlegium, one of the higheſt mountains in Æthiopia; which, after one night's concuſſion, was never ſeen more. In more modern times, a very noted mountain in the Molucca iſlands, known by the name of the Peak, and remarkable for being ſeen at a very great diſtance from ſea, was ſwallowed by an earthquake; and nothing but a lake was left in the place where it ſtood. Thus, while ſtorms and tempeſts are levelled againſt mountains above, earthquakes and waters are undermining them below. All our hiſtories talk of their deſtruction; and very few new ones (if we except Mount Cenere, and one or two ſuch heaps of cinders) are produced. If mountains, therefore, were of ſuch great utility as ſome philoſophers make them to mankind, it would be a very melancholy conſideration that ſuch benefits were diminiſhing every day. But the truth is, the valleys are fertilized by that earth which is waſhed from

* Plin. l. 2. cap. 93.

their

their ſides; and the plains become richer, in proportion as the mountains decay.

CHAP. XIII.

Of Water.

IN contemplating nature, we ſhall often find the ſame ſubſtances poſſeſſed of contrary qualities, and producing oppoſite effects. Air, which liquifies one ſubſtance, dries up another. That fire which is ſeen to burn up the deſart, is often found, in other places, to aſſiſt the luxuriance of vegetation; and water, which, next to fire, is the moſt fluid ſubſtance upon earth, nevertheleſs, gives all other bodies their firmneſs and durability; ſo that every element ſeems to be a powerful ſervant, capable either of good or ill, and only awaiting external direction, to become the friend or the enemy of mankind. Theſe oppoſite qualities, in this ſubſtance in particular, have not failed to excite the admiration and enquiry of the curious.

That water is the moſt fluid penetrating body, next to fire, and the moſt difficult to confine, is inconteſtibly proved by a variety of experiments. A veſſel through which water cannot paſs, may be ſaid to retain any

thing. It may be objected, indeed, that ſyrups, oils, and honey, leak through ſome veſſels that water cannot paſs through; but this is far from being the reſult of the greater tenuity and fineneſs of their parts; it is owing to the roſin wherewith the wood of ſuch veſſels abounds, which oils and ſyrups have a power of diſſolving; ſo that theſe fluids, inſtead of finding their way, may more properly be ſaid to eat their way through the veſſels that contain them. However, water will at laſt find its way even through theſe; for it is known to eſcape through veſſels of every ſubſtance, glaſs only excepted. Other bodies may be found to make their way out more readily indeed; as air, when it finds a vent, will eſcape at once; and quickſilver, becauſe of its weight, quickly penetrates through whatever chinky veſſel confines it: but water, tho' it operates more ſlowly, yet always finds a more certain iſſue. As, for inſtance, it is well known that air will not paſs through leather; which water will very readily penetrate. Air alſo may be retained in a bladder; but water will quickly ooze through. And thoſe who drive this to the greateſt degree of preciſion, pretend to ſay, that it will paſs through pores ten times ſmaller than air can do. Be this as it may, we are very certain that its parts are ſo ſmall

that

that they have been actually driven through the pores of gold. This has been proved by the famous Florentine experiment, in which a quantity of water was ſhut up in an hollow ball of gold, and then preſſed with an huge force by ſcrews, during which the fluid was ſeen to ooze out through the pores of the metal, and to ſtand, like a dew, upon its ſurface.

As water is thus penetrating, and its parts thus minute, it may eaſily be ſuppoſed that they enter into the compoſition of all bodies, both vegetable, animal, and foſſil. This every chemiſt's experience convinces him of; and the mixture is the more obvious, as it can always be ſeparated, by a gentle heat, from thoſe ſubſtances with which it had been united. Fire, as was ſaid, will penetrate where water cannot paſs; but then it is not ſo eaſily to be ſeparated. But there is ſcarce any ſubſtance from which its water cannot be divorced. The parings or filings of lead, tin, and antimony, by diſtillation, yield water plentifully: the hardeſt ſtones, ſea ſalt, nitre, vitriol, and ſulphur, are found to conſiſt chiefly of water; into which they reſolve by force of fire. "All birds, beaſts, and fiſhes," ſays Newton, "inſects, trees, and vegetables, with their parts, grow from water; and, by putrefaction, return to water again."

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In ſhort, almoſt every ſubſtance that we ſee, owes its texture and firmneſs to the parts of water that mix with its earth; and, deprived of this fluid, it falls away, into a maſs of ſhapeleſs duſt and aſhes.

From hence we ſee, as was above hinted, that this moſt fluid body, when mixed with others, gives them conſiſtence and form. Water, by being mixed with earth or aſhes, and formed into a veſſel, when baked before the fire, becomes a copel, remarkable for this, that it will bear the utmoſt force of the hotteſt furnace that art can contrive. So the Chineſe earth, of which porcelane is made, is nothing more than an artificial compoſition of the earth and water, united by heat; and which a greater degree of heat could eaſily ſeparate. Thus we ſee a body, extremely fluid of itſelf, in ſome meaſure aſſuming a new nature, by being united with others; we ſee a body, whoſe fluid and diſſolving qualities are ſo obvious, giving conſiſtence and hardneſs to all the ſubſtances of the earth.

From conſiderations of this kind, Thales, and many of the ancient philoſophers, held that all things were made of water. In order to confirm this opinion, Helmont made an experiment, by diveſting a quantity of earth of all its oils and ſalts, and then putting this

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earth, ſo prepared into an earthen pot, which nothing but rain water could enter, and planting a willow therein; this vegetable, ſo planted, grew up to a conſiderable heighth and bulk, merely from the accidental aſperſion of rain-water; while the earth in which it was planted, received no ſenſible diminution. From this experiment, he concluded, that water was the only nouriſhment of the vegetable tribe; and that vegetables, being the nouriſhment of animals, all organiſed ſubſtances, therefore, owed their ſupport and being only water. But this has been ſaid by Woodward to be all a miſtake: for he ſhews, that water being impregnated with earthy particles, is only the conveyer of ſuch ſubſtances into the pores of vegetables, rather than an encreaſer of them, by its own bulk: he ſhews, that water is ever found to afford ſo much leſs nouriſhment, in proportion as it is purified by diſtillation. A plant in diſtilled water will not grow ſo faſt as in water not diſtilled: and if the ſame be diſtilled three or four times over, the plant will ſcarce grow at all, or receive any nouriſhment from it. So that water, as ſuch, does not ſeem the proper and only nouriſhment of vegetables, but only the vehicle thereof, which contains the nutritious particles, and carries them through all parts of the plant. Water in

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its pure ſtate, may ſuffice to extend or ſwell the parts of a plant, but affords vegetable matter in a moderate proportion.

However this be, it is agreed on all ſides, that water, ſuch as we find it, is far from being a pure ſimple ſubſtance. The moſt genuine, we know, is mixed with exhalations and diſſolutions of various kinds; and no expedient that has been hitherto diſcovered, is capable of purifying it entirely. If we filter and diſtil it a thouſand times, according to Boerhaave, it will ſtill depoſe a ſediment: and by repeating the proceſs, we may evaporate it entirely away, but can never totally remove its impurities. Some, however, aſſert, that water, properly diſtilled, will have no ſediment *; and that the little white ſpeck which is found at the bottom of the ſtill, is a ſubſtance that enters from without. Kircher uſed to ſhew, in his Muſæum, a phial of water, that had been kept for fifty years, hermetically ſealed †; during which time it depoſed no ſediment, but continued as tranſparent as when firſt it was put

* Hill's Hiſtory of Foſſils. † Hermetically ſealing a glaſs-veſſel, means no more than heating the mouth of the phial red hot; and thus when the glaſs is become pliant, ſqueezing the mouth together with a pair of pincers, and then twiſting it ſix or ſeven times round, which effectually cloſes it up.

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in. How far, therefore, it may be brought to a ſtate of purity by diſtillation, is unknown; but we very well know, that all ſuch water as we every where ſee, is a bed in which plants, minerals, and animals, are all found confuſedly floating together.

Rain-water, which is a fluid of Nature's own diſtilling, and which has been raiſed ſo high by evaporation, is, nevertheleſs, a very mixed and impure ſubſtance. Exhalations of all kinds, whether ſalts, ſulphurs, or metals, make a part of its ſubſtance, and tend to increaſe its weight. If we gather the water that falls, after a thunder-clap, in a ſultry ſummer's day, and let it ſettle, we ſhall find a real ſalt ſticking at the bottom. In winter, however, its impure mixtures are fewer; but ſtill may be ſeparated by diſtillation. But as to that which is generally caught pouring from the tops of houſes, it is particularly foul, being impregnated with the ſmoak of the chimnies, the vapour of the ſlates or tiles, and with other impurities that birds and animals may have depoſited there. Beſides, though it ſhould be ſuppoſed free from all theſe, it is mixed with a quantity of air, which, after being kept for ſome time, will be ſeen to ſeparate.

Spring-

Spring-water is next in point of purity. This, according to Doctor Halley, is collected from the air itself; which being fated with water, and coming to be condenſed by the evening's cold, is driven againſt the tops of the mountains, where being condenſed, and collected, it trickles down by the ſides, into the cavities of the earth; and running for a while under ground, bubbles up in fountains upon the plain. This having made but a ſhort circulation, has generally had no long time to diſſolve or imbibe any foreign ſubſtances by the way.

River-water is generally more foul than the former. Wherever the ſtream flows, it receives a tincture from its channel. Plants, minerals, and animals, all contribute their ſhare to add to its impurities: ſo that ſuch as live at the mouths of great rivers, generally are ſubject to all thoſe diſorders which contaminated and unwholſome waters are known to produce. Of all the river-water in the world, that of the Indus, and the Thames, are ſaid to be moſt light and wholeſome.

The impureſt freſh water that we know, is that of ſtagnating pools and lakes, which, in ſummer, may be more properly conſidered as a jelly of floating inſects, than a collection

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of water. In this, millions of little reptiles, undiſturbed by any current, which might cruſh their frames to pieces, breed and engender. The whole teems with ſhapeleſs life; and only grows more fruitful by encreaſing putrefaction.

Of the purity of all theſe waters, the lightneſs, and not the tranſparency, ought to be the teſt. Water may be extremely clear and beautiful to the eye, and yet very much impregnated with mineral principles. In fact, ſea-water is the moſt tranſparent of any, and yet is well known to contain a large mixture of ſalt and bitumen. On the contrary, thoſe waters which are lighteſt, have the feweſt diſſolutions floating in them; and may, therefore, be the moſt uſeful for all the purpoſes of life. But, after all, though much has been ſaid upon this ſubject, and although waters have been weighed with great aſſiduity, to determine their degree of ſalubrity, yet neither this, nor their curdling with ſoap, nor any other philoſophical ſtandard whatſoever, will anſwer the purpoſes of the true information. Experience alone ought to determine the uſeful, or noxious qualities, of every ſpring; and experience aſſures us, that different kinds of water are adapted to different conſtitutions. An inconteſtible proof of this, are the many medicinal ſprings through-

throughout the world, whoſe peculiar benefits are known to the natives of their reſpective countries. Theſe are of various kinds, according to the different minerals with which they are impregnated; hot, ſaline, ſulphureous, bituminous, and oily. But the account of theſe will come moſt properly under that of the ſeveral minerals by which they are produced.

After all, therefore, we muſt be contented with but an impure mixture for our daily beverage. And yet, perhaps, this very mixture may often be more ſerviceable to our health than that of a purer kind. We know that it is ſo with regard to vegetables: and why not, alſo, in general, to man? Be this as it will, if we are deſirous of having water in its greateſt purity, we are ordered, by the curious in this particular, to diſtil it from ſnow, gathered upon the tops of the higheſt mountains, and to take none but the outer and ſuperficial part thereof. This we muſt be ſatisfied to call pure water; but even this is far ſhort of the pure unmixed philoſophical element; which, in reality, is no where to be found.

As water is thus mixed with foreign matter, and often the repoſitory of minute animals, or vegetable ſeeds, we need not be ſurprized that, when carried to ſea, it is always found

found to putrefy. But we muſt not ſuppoſe that it is the element itſelf, which thus grows putrid, and offenſive, but the ſubſtances with which it is impregnated. It is true, the utmoſt precautions are taken to deſtroy all vegetable and animal ſubſtances that may have previouſly been lodged in it, by boiling: but, notwithſtanding this, there are ſome that will ſtill ſurvive the operation; and others, that find their way during the time of its ſtowage. Seamen, therefore, aſſure us, that their water is generally found to putrefy twice, at leaſt, and ſometimes three times, in a long voyage. In about a month after it has been at ſea, when the bung is taken out of the caſk, it ſends up a noiſome and dangerous vapour, which would take fire upon the application of a candle *. The whole body of the water then is found replete with little worm-like inſects, that float, with great briſkneſs, through all its parts. Theſe generally live for about a couple of days; and then dying, by depoſiting their ſpoils, for a while encreaſe the putrefaction. After a time, the heavier parts of theſe ſinking to the bottom, the lighter float, in a ſcum, at the top; and this is what the mariners call, the water's purging itſelf. There are ſtill, how-

* Phil. Tranſ. vol. v. part ii. p. 71.

ever,

ever, another race of inſects, which are bred, very probably, from the ſpoils of the former; and produce, after ſome time, ſimilar appearances: theſe dying, the water is then thought to change no more. However, it very often happens, eſpecially in hot climates, that nothing can drive theſe nauſeous inſects from the ſhip's ſtore of water. They often encreaſe to a very diſagreeable and frightful ſize, ſo as to deter the mariner, though parching with thirſt, from taſting that cup which they have contaminated.

This water, as thus deſcribed, therefore, is a very different fluid from that ſimple elementary ſubſtance upon which philoſophical theories have been founded; and concerning the nature of which there have been ſo many diſputes. Elementary water is no way compounded; but is without taſte, ſmell, or colour; and incapable of being diſcerned by any of the ſenſes, except the touch. This is the famous diſſolvent of the chymiſts, into which, as they have boaſted, they can reduce all bodies; and which makes up all other ſubſtances, only by putting on a different diſguiſe. In ſome forms, it is fluid, tranſparent, and evaſive of the touch; in others, hard, firm, and elaſtic. In ſome, it is ſtiffened by cold; in others, diſſolved by fire. According to them, it only aſſumes external

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ſhapes from accidental cauſes; but the mountain is as much a body of water as the cake of ice that melts on its brow; and even the philoſopher himſelf, is compoſed of the ſame materials with the cloud or meteor which he contemplates.

Speculation ſeldom reſts when it begins. Others, diſallowing the univerſality of this ſubſtance, will not allow that in a ſtate of nature there is any ſuch thing as water at all. What aſſumes the appearance, ſay they, is nothing more than melted ice. Ice is the real element of Nature's making; and when found in a ſtate of fluidity, it is then in a ſtate of violence. All ſubſtances are naturally hard; but ſome more readily melt with heat than others. It requires a great heat to melt iron; a ſmaller heat will melt copper: ſilver, gold, tin, and lead, melt with ſmaller ſtill: ice, which is a body like the reſt, melts with a very moderate warmth; and quickſilver, melts with the ſmalleſt warmth of all. Water, therefore, is but ice kept in continual fuſion; and ſtill returning to its former ſtate, when the heat is taken away. Between theſe oppoſite opinions, the controverſy has been carried on with great ardour; and much has been written on both ſides: and yet, when we come to examine the debate, it will probably

bably terminate in this queſtion, whether cold or heat firſt began their operations upon water? This is a fact of very little importance, if known; and what is more, it is a fact we can never know.

Indeed, if we examine into the operations of cold and heat upon water, we ſhall find that they produce ſomewhat ſimilar effects. Water dilates in its bulk, by heat, to a very conſiderable degree; and, what is more extraordinary, it is likewiſe dilated by cold, in the ſame manner.

If water be placed over a fire, it grows gradually larger in bulk, as it becomes hot, until it begins to boil; after which, no art can either encreaſe its bulk, or its heat. By encreaſing the fire, indeed, it may be more quickly evaporated away; but its heat, and its bulk, ſtill continue the ſame. By the expanding of this fluid by heat, philoſophers have found a way to determine the warmth, or the coldneſs of other bodies: for if put into a glaſs tube, by its ſwelling and riſing therein, it ſhews the quantity of heat in the body to which it is applied; by its contracting, and ſinking, it ſhews the abſence of the ſame. Inſtead of uſing water in this inſtrument, which is called a thermometer, they now make uſe of ſpirit of wine, which is not apt to freeze, and which is endued even with a

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greater expanſion, by heat, than water. The inſtrument conſiſts of nothing more than a hollow ball of glaſs, with a long tube growing out of it. This being partly filled with ſpirits of wine, tinctured red, ſo as to be ſeen when it riſes, the ball is plunged into boiling water, which making the ſpirit within expand and riſe in the tube, the water marks the greateſt height to which it aſcends; at this point the tube is to be broken off, and then hermetically ſealed, by melting the glaſs with a blow-pipe: a ſcale being placed by the ſide, completes the thermometer. Now as the fluid expands or condenſes with heat or cold, it will riſe and fall in the tube in proportion; and the degree or quantity of aſcent or deſcent will be ſeen in the ſcale.

No fire, as was ſaid, can make water hotter, after it begins to boil. We can, therefore, at any time be ſure of an equable certain heat; which is that of boiling water, which is invariably the ſame. The certainty of ſuch an heat is not leſs uſeful than the inſtrument that meaſures it. It affords a ſtandard, fixed, degree of heat over the whole world; boiling water being as hot in Greenland, as upon the coaſts of Guinea. One fire is more intenſe than another; of heat there are various degrees; but boiling water is an heat every where the ſame, and eaſily procurable.

As heat thus expands water, ſo cold, when it is violent enough to freeze the ſame, produces exactly the ſame effect, and expands it likewiſe. Thus the water is acted upon in the ſame manner by two oppoſite qualities; being dilated by both. As a proof that it is dilated by cold, we have only to obſerve the ice which floats on the ſurface of a pond, which it would not do were it not dilated, and grown more bulky, by freezing, than the water, which remains unfroze. Mr. Boyle, however, put the matter paſt a doubt, by a variety of experiments*. Having poured a proper quantity of water into a ſtrong earthen veſſel, he expoſed it, uncovered, to the open air, in froſty nights; and obſerved, that continually the ice reached higher than the water, before it was frozen. He filled alſo a tube with water, and ſtopped both ends with wax: the water, when froze, was found to puſh out the ſtopples from both ends; and a rod of ice appeared at each end of the tube, which ſhewed how much it was ſwollen by the cold within.

From hence, therefore, we may be very certain of the cold's dilating of the water; and experience alſo ſhews that, the force of this expanſion has been found as great as any

* Boyle, vol. i. p. 610.

which

which heat has been found to produce. The touch-hole of a ſtrong gun-barrel being ſtopped, and a plug of iron forcibly driven into the muzzle, after the barrel had been filled with water, it was placed in a mixture of ice and ſalt; the plug, though ſoldered to the barrel, at firſt gave way, but being fixed in more firmly, within a quarter of an hour the gun-barrel burſt with a loud noiſe, and blew up the cover of the box wherein it lay. Such is its force in an ordinary experiment. But it has been known to burſt cannons, filled with water, and then left to freeze; for the cold congealing the water, and the ice ſwelling, it became irreſiſtible. The burſting of rocks, by froſt, which is frequent enough in the Northern climates, and is ſometimes ſeen in our own, is an equal proof of the expanſion of congealed water. For having, by ſome means inſinuated itſelf into the body of the rock, it has remained there till the cold was ſufficient to affect it by congelation. But when once frozen, no obſtacle is able to confine it from dilating; and, if it cannot otherwiſe find room, the rock muſt burſt aſunder.

This alteration in the bulk of water, might have ſerved as a proof that it was capable of being compreſſed into a narrower ſpace than it occupied before; but, till of

late, water was held to be incompreſſible. The general opinion was, that no art whatſoever could ſqueeze it into a narrower compaſs; that no power on earth, for inſtance, could cruſh a pint of water into a veſſel that held an hair's breadth leſs than a pint. And this, ſaid they, appears from the famous Florentine experiment; where the water, rather than ſuffer compreſſure, was ſeen to ooze out through the pores of the ſolid metal; and, at length, making a cleft in the ſide, ſpun out with great vehemence. But later trials have proved that water is very compreſſible, and partakes of that elaſticity which every other body poſſeſſes in ſome degree. Indeed, had not mankind been dazzled by the brilliancy of one inconcluſive experiment, there were numerous reaſons to convince them of its having the ſame properties with other ſubſtances. Ice, which is water in another ſtate, is very elaſtic. A ſtone flung ſlantingly along the ſurface of a pond, bounds from the water ſeveral times; which ſhews it to be elaſtic alſo. But the trials of Mr. Canton have put this paſt all doubt; which being ſomewhat ſimilar to thoſe of the great Boyle, who preſſed it with weights properly applied, carry ſufficient conviction.

What has been hitherto related, is chiefly applicable to the element of water alone; but

but its fluidity is a property that it poſſeſſes in common with ſeveral other ſubſtances, in other reſpects greatly differing from it. That quality which gives riſe to the definition of a fluid, namely, that its parts are in a continual inteſtine motion, ſeems extremely applicable to water. What the ſhapes of thoſe parts are, it would be vain to attempt to diſcover. Every trial only ſhews the futility of the attempt; all we find is, that they are extremely minute; and that they roll over each other with the greateſt eaſe. Some, indeed, from this property alone, have not heſitated to pronounce them globular; and we have, in all our hydroſtatical books, pictures of theſe little globes in a ſtate of ſliding and rolling over each other. But all this is merely the work of imagination; we know that ſubſtances of any kind, reduced very ſmall, aſſume a fluid appearance, ſomewhat reſembling that of water. Mr. Boyle, after finely powdering and ſifting a little dry powder of plaiſter of Paris, put it in a veſſel over the fire, where it ſoon began to boil like water, exhibiting all the motions and appearances of a boiling liquor. Although but a powder, the parts of which we know are very different from each other, and juſt as accident has formed them, yet it heaved in great waves, like water. Upon agitation,

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an heavy body will ſink to the bottom, and a light one emerge to the top. There is no reaſon, therefore, to ſuppoſe the figure of the parts of water round, ſince we ſee their fluidity very well imitated by a compoſition, the parts of which are of various forms and ſizes. The ſhape of the parts of water, therefore, we muſt be content to continue ignorant of. All we know is, that earth, air, and fire, all conduce to ſeparate the parts from each other.

Earthy ſubſtances divide the parts from each other, and keep them aſunder. This diviſion may be ſo great, that the water will entirely loſe its fluidity thereby. Mud, potter's clay, and dried bricks, are but ſo many different combinations of earth and water; each ſubſtance in which the parts of water are moſt ſeparated from each other, appearing to be the moſt dry. In ſome ſubſtances, indeed, where the parts of water are greatly divided, as in porcelane, for inſtance, it is no eaſy matter to recover and bring them together again; but they continue in a manner fixed and united to the manufactured clay. This circumſtance it was, which led Doctor Cheney into a very peculiar ſtrain of thinking. He ſuſpected that the quantity of water, on the ſurface of the earth, was daily decreaſing. For, ſays he,

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ſome parts of it are continually joined to vegetable, animal, and mineral ſubſtances, which no art can again recover. United with theſe, the water loſes its fluidity; for if, continues he, we ſeparate a few particles of any fluid, and faſten them to a ſolid body, or keep them aſunder, one from another, they will be fluid no longer. To produce fluidity, a conſiderable number of ſuch particles are required; but here they are cloſe, and deſtitute of their natural properties. Thus, according to him, the world is growing every day harder and harder, and the earth firmer and firmer; and there may come a time when every object around us may be ſtiffened in univerſal frigidity! However, we have cauſes enough of anxiety in this world already, not to add this prepoſterous concern to the number.

That air alſo contributes to divide the parts of water, we can have no manner of doubt of; ſome have even diſputed whether water be not capable of being turned into air. However, though this muſt not be allowed, it muſt be granted, that it may be turned into a ſubſtance which greatly reſembles air (as we have ſeen in the experiment of the œolpile) with all its properties; except that, by cold, this new made air may be condenſed again into water.

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But of all the ſubſtances which tend to divide the parts of water, fire is the moſt powerful. Water, when heated into ſteam, acquires ſuch force, and the parts of it tend to fly off from each other with ſuch violence, that no earthly ſubſtance we know of, is ſtrong enough to confine them. A ſingle drop of water, converted into ſteam, has been found capable of raiſing a weight of twenty tons; and would have taiſed twenty thouſand, were the veſſel confining it ſufficiently ſtrong, and the fire below encreaſed in proportion.

From this eaſy yielding of its parts to external preſſure, ariſes the art of determining the bulk of bodies by plunging them in water; with all the other uſeful diſcoveries in that part of natural philoſophy, called hydroſtatics. The laws of this ſcience, which Archimedes firſt began, and Paſcal, with ſome other of the moderns, brought to perfection, rather belongs to experimental than to natural hiſtory. However, I will take leave to mention ſome of the moſt ſtriking paradoxes in this branch of ſcience, which are as well confirmed by experiment, as rendered univerſal by theory. It would, indeed, be unpardonable, while diſcourſing on the properties of water, to omit giving ſome account of the manner in which it ſuſtains ſuch immenſe bulks as we ſee floating upon its

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ſoft and yielding ſurface: how ſome bodies, that are known to ſink at one time, ſwim with eaſe, if their ſurface be enlarged: how the heavieſt body, even gold itſelf, may be made to ſwim upon water; and how the lighteſt, ſuch as cork, ſhall remain ſunk at the bottom: how the pouring in of a ſingle quart of water, will burſt an hogſhead hooped with iron: and how it aſcends, in pipes, from the valley, to travel over the mountain: theſe are circumſtances that are at firſt ſurprizing; but, upon a ſlight conſideration, loſe their wonder.

*In order to conceive the manner in which all theſe wonders are effected, we muſt begin by obſerving that water is poſſeſſed of an invariable property, which has not hitherto been mentioned; that of always keeping its ſurface level and even. Winds, indeed, may raiſe it into waves; or art ſpurt it up in fountains; but ever, when left to itſelf, it ſinks into a ſmooth even ſurface, of which no one part is higher than another. If I ſhould pour water, for inſtance, into the arm of a pipe of the ſhape of the letter U, the fluid would riſe in the other arm juſt to the ſame height; becauſe, otherwiſe, it would not find its level, which it invariably

* In the above ſketch, the manner of demonſtrating uſed by Monſieur D'Alambert is made uſe of, as the moſt obvious, and the moſt ſatisfactory. Vide Eſſai ſur, &c.

maintains.

maintains. A pipe bending from one hill down into the valley, and riſing by another, may be conſidered as a tube of this kind, in which the water, ſinking in one arm, riſes to maintain its level in the other. And upon this principle all water-pipes depend; which can never raiſe the water higher than the fountain from which they proceed.

Again, let us ſuppoſe for a moment, that the arms of the pipe already mentioned, may be made long or ſhort at pleaſure; and let us ſtill further ſuppoſe, that there is ſome obſtacle at the bottom of it, which prevents the water poured into one arm, from riſing in the other. Now it is evident, that this obſtacle at the bottom will ſuſtain a preſſure from the water in one arm, equal to what would make it riſe in the other; and this preſſure will be great, in proportion as the arm filled with water is tall. We may, therefore, generally conclude, that the bottom of every veſſel is preſſed by a force, in proportion to the height of the water in that veſſel. For inſtance, if the veſſel filled with water be forty feet high, the bottom of that veſſel will ſuſtain ſuch a preſſure as would raiſe the ſame water forty feet high, which is very great. From hence we ſee how extremely apt to burſt our pipes that convey water to the city are; for deſcending from

an

an hill of more than forty feet high, they are preſſed by the water contained in them, with a force equal to what would raiſe it more than forty feet high; and that this is ſometimes able to burſt a wooden pipe, we can have no room to doubt of.

Still recurring to our pipe, let us ſuppoſe one of its arms ten times as thick as the other; this will produce no effect whatſoever upon the obſtacle below, which we ſuppoſed hindering its riſe in the other arm; becauſe, how thick ſoever the pipe may be, its contents would only riſe to its own level; and it will, therefore, preſs the obſtacle with a force equal thereto. We may, therefore, univerſally conclude, that the bottom of any veſſel is preſſed by its water, not as it is broad or narrow, but in proportion as it is high. Thus the water contained in a veſſel not thicker than my finger, preſſes its bottom as forcibly as the water contained in an hogſhead of an equal height; and, if we made holes in the bottoms of both, the water would burſt out as forceful from the one as the other. Hence we may, with great eaſe, burſt an hogſhead with a ſingle quart of water; and it has been often done. We have only *, for this, to place an hogſhead on one end, filled with water: we then bore an

* Nollet's Lectures.

hole

hole in its top, into which we plant a narrow tin pipe, of about thirty feet high: by pouring a quart of water into this, at the top, as it continues to riſe higher in the pipe, it will preſs more forcibly on the bottom and ſides of the hogſhead below, and at laſt burſt it.

Still returning to our ſimple inſtrument of demonſtration. If we ſuppoſe the obſtacle at the bottom of the pipe to be moveable, ſo as that the force of the water can puſh it up into the other arm; ſuch a body is quickſilver, for inſtance. Now, it is evident, that the weight of water weighing down upon this quickſilver in one arm, will at laſt preſs it up in the other arm; and will continue to preſs it upwards, until the fluid in both arms be upon a par. So that here we actually ſee quickſilver, the heavieſt ſubſtance in the world, except gold, floating upon water, which is but a very light ſubſtance.

When we ſee water thus capable of ſuſtaining quickſilver, we need not be ſurprized that it is capable of floating much lighter ſubſtances, ſhips, animals, or timber. When any thing floats upon water, we always ſee that a part of it ſinks in the ſame. A cork, a ſhip, a buoy, each buries itſelf a bed on the ſurface of the water; this bed may be conſidered as ſo much water diſplaced; the water will, therefore, loſe ſo much of its own

own weight as is equal to the weight of that bed of water which it diſplaces. If the body be heavier than a ſimilar bulk of water, it will ſink; if lighter, it will ſwim. Univerſally, therefore, every body that is plunged in water, loſes as much of its weight as is equal to the weight of a body of water of its own bulk. Some light bodies, therefore, ſuch as cork, loſe all their weight, and therefore ſwim, becauſe their bulk of water is heavier than they; other more ponderous bodies ſink, becauſe they are heavier than their bulk of water.

Upon this ſimple theorem entirely depends the art of weighing metals hydroſtatically. I have a guinea, for inſtance, and deſire to know whether it be pure gold: I have weighed it in the uſual way with another guinea, and find it exactly of the ſame weight, but ſtill I have ſome ſuſpicion, from its greater bulk, that it is not pure. In order to determine this, I have nothing more to do than to weigh it in water with that ſame guinea that I know to be good, and of the ſame weight; and this will inſtantly ſhew the difference; for the true ponderous metal will ſink, and the falſe bulky one will be ſuſtained in proportion to the greatneſs of its ſurface. Thoſe whoſe buſineſs it is to examine the purity of metals, have a balance made

made for this purpoſe, by which they can preciſely determine which is moſt ponderous, or, as it is expreſſed, which has the greateſt ſpecific gravity. Seventy-one pound and an half of quickſilver is found to be equal in bulk to an hundred pound weight of gold. In the ſame proportion, ſixty of lead, fifty-four of ſilver, forty-ſeven of copper, forty-five of braſs, forty-two of iron, and thirty-nine of tin, are each equal to an hundred pound of the ſame moſt ponderous of all metals.

This method of preciſely determining the purity of gold, by weighing in water, was firſt diſcovered by Archimedes, to whom mankind have been indebted for many of the moſt uſeful diſcoveries. Hiero, king of Sicily, having ſent a certain quantity of gold to be made into a crown, the workman, it ſeems, kept a part for his own uſe, and ſupplied the deficiency with a baſer metal. His fraud was ſuſpected by the king, but could not be proved; till applying to Archimedes, he weighed the crown in water; and, by this method, directly informed the king of the quantity of gold which was taken away.

It has been ſaid, that all fluids endeavour to preſerve their level; and, likewiſe, that a body preſſing on the ſurface, tended to deſtroy that level. From hence, therefore, it will

eaſily be inferred, that the deeper any body ſinks, the greater will be the reſiſtance of the depreſſed fluid beneath. It will be aſked, therefore, as the reſiſtance encreaſes in proportion as the body deſcends, how comes the body, after it is got a certain way, to ſink at all? The anſwer is obvious. From the fluid above it preſſing it down with almoſt as great a force as the fluid beneath preſſes it up. Take away, by any art, the preſſure of the fluid from above, and let only the reſiſtance of the fluid from below be ſuffered to act, and after the body is got down very deep, the reſiſtance will be inſuperable. To give an inſtance: a ſmall hole opens in the bottom of a ſhip at ſea, forty feet we will ſuppoſe below the ſurface of the water; through this the water burſts up with great violence; I attempt to ſtop it with my hand, but it puſhes the hand violently away. Here the hand is, in fact, a body attempting to ſink upon water, at a depth of forty feet, with the preſſure from above taken away. The water, therefore, will overcome my ſtrength; and will continue to burſt in till it has got to its level: if I ſhould then dive into the hold, and clap my hand upon the opening, as before, I ſhould perceive no force acting againſt my hand at all, for the water above preſſes the hand as much down againſt the hole, as the

water

water without preſſes it upward. For this reaſon, alſo, when we dive to the bottom of the water, we ſuſtain a very great preſſure from above, it is true, but it is counteracted by the preſſure from below; and the whole acting uniformly on the ſurface of the body, wraps us cloſe round without injury.

As I have deviated thus far, I will juſt mention one or two properties more, which water, and all ſuch like fluids, is found to poſſeſs. And firſt, their aſcending in veſſels which are emptied of air, as in our common pumps for inſtance. The air, however, being the agent in this caſe, we muſt previouſly examine the properties of that, before we undertake the explanation. The other property to be mentioned is, that of their aſcending in ſmall capillary tubes. This is one of the moſt extraordinary and inſcrutable appearances in nature. Glaſs tubes may be drawn, by means of a lamp, as fine as an hair; ſtill preſerving their hollow within. If one of theſe be planted in a veſſel of water, or ſpirit of wine, the liquor will immediately be ſeen to aſcend; and it will riſe higher, in proportion as the tube is ſmaller; a foot, two feet, and more. How does this come to paſs? Is the air the cauſe? No: the liquor riſes, although the air be taken away. Is attraction the cauſe? No: for quickſilver

does

does not aſcend, which it otherwiſe would. Many have been the theories of experimental philoſophers to explain this property. Such as are fond of travelling in the regions of conjecture, may conſult Hawkſbee, Morgan, Jurin, or Watſon, who have examined the ſubject with great minuteneſs. Hitherto, however, nothing but doubts inſtead of knowlege have been the reſult of their enquiries. It will not, therefore, become us to enter into the minuteneſs of the enquiry, when we have ſo many greater wonders to call our attention away.

CHAP. XIV.

Of the Origin of Rivers.

THE ſun ariſeth, and the ſun goeth down, and pants for the place from whence he aroſe. All things are filled with labour, and man cannot utter it. All rivers run into the ſea, yet the ſea is not full. Unto the place whence the rivers come, thither they return again. The eye is not ſatisfied with ſeeing, nor the ear with hearing*. Thus ſpeaks the wiſeſt of the Jews. And, at ſo

* Eccleſiaſtes, chap. i. v. 5, 7, 8.

early a period was the curioſity of man employed in obſerving theſe great circulations of nature. Every eye attempted to explain thoſe appearances; and every philoſopher who has long thought upon the ſubject, ſeems to give a peculiar ſolution. The enquiry whence rivers are produced; whence they derive thoſe unceaſing ſtores of water, which continually enrich the world with fertility and verdure; has been variouſly conſidered; and divided the opinions of mankind, more than any other topic in natural hiſtory.

In this conteſt, the various champions may be claſſed under two leaders, Mr. De La Hire, who contends that rivers muſt be ſupplied from the ſea, ſtrained through the pores of the earth; and Doctor Halley, who has endeavoured to demonſtrate, that the clouds alone are ſufficient for the ſupply. Both ſides have brought in mathematics to their aid; and have ſhewn, that long and laborious calculations can at any time be made, to obſcure both ſides of a queſtion.

De La Hire * begins his proofs, that rain-water, evaporated from the ſea, is inſufficient for the production of rivers; by ſhewing, that rain never penetrates the ſurface of the earth above ſixteen inches. From thence he

* Hiſt. de l'Acad. 1713, p. 56.

infers,

infers, that it is impoſſible for it, in many caſes, to ſink ſo as to be found at ſuch conderable depths below. Rain-water, he grants, is often ſeen to mix with rivers, and to ſwell their currents; but a much greater part of it evaporates away. In fact, continues he, if we ſuppoſe the earth every where covered with water, evaporation alone would be ſufficient to carry off two feet nine inches of it in a year: and yet, we very well know, that ſcarce nineteen inches of rain-water falls in that time; ſo that evaporation would carry off a much greater quantity than is ever known to deſcend. The ſmall quantity of rain-water that falls is therefore but barely ſufficient for the purpoſes of vegetation. Two leaves of a fig-tree have been found, by experiment, to imbibe from the earth, in five hours and an half, two ounces of water. This implies the great quantity of fluid that muſt be exhauſted in the maintenance of one ſingle plant. Add to this, that the waters of the river Rungis will, by calculation, riſe to fifty inches; and the whole country from whence they are ſupplied, never receives fifty inches, in the year, by rain. Beſides this, there are many ſalt ſprings, which are known to proceed immediately from the ſea, and are ſubject to its flux and reflux. In ſhort, where-

ever we dig beneath the ſurface of the earth, except in a very few inſtances, water is to be found and it is by this ſubterraneous water, that ſprings and rivers, nay, a great part of vegetation itſelf, is ſupported. It is this ſubterraneous water, which is raiſed into ſteam, by the internal heat of the earth, that feeds plants. It is this ſubterraneous water that diſtils through its interſtices; and there cooling, forms fountains. It is this that, by the addition of rains, is encreaſed into rivers; and pours plenty over the whole earth.

On the other ſide of the queſtion*, it is aſſerted, that the vapours which are exhaled from the ſea, and driven by the winds upon land, are more than ſufficient to ſupply not only plants with moiſture, but alſo to furniſh a ſufficiency of water to the greateſt rivers. For this purpoſe, an eſtimate has been made of the quantity of water emptied at the mouths of the greateſt rivers; and of the quantity alſo raiſed from the ſea by evaporation; and it has been found, that the latter by far exceeds the former. This calculation was made by Mr. Mariotte. By him it was found, upon receiving ſuch rain as fell in a year, in a proper veſſel, fitted for that purpoſe, that, one year with another, there might fall about twenty inches of

* Phil. Tranſ. vol. ii. p. 128.

water

water upon the ſurface of the earth, throughout Europe. It was alſo computed, that the river Seine, from its ſource to the city of Paris, might cover an extent of ground, that would ſupply it annually with above ſeven billions of cubic feet of this water, formed by evaporation. But, upon computing the quantity which paſſed through the arches of one of its bridges in a year, it was found to amount only to two hundred and eighty millions of cubic feet, which is not above the ſixth part of the former number. Hence, therefore, it appears, that this river may receive a ſupply brought to it by the evaporated waters of the ſea, ſix times greater than what it gives back to the ſea by its current; and, therefore, evaporation is more than ſufficient for maintaining the greateſt rivers; and ſupplying the purpoſes alſo of vegetation.

In this manner the ſea ſupplies ſufficient humidity to the air for furniſhing the earth with all neceſſary moiſture. One part of its vapours fall upon its own boſom, before they arrive upon land. Another part is arreſted by the ſides of mountains, and is compelled, by the riſing ſtream of air, to mount upward towards the ſummits. Here it is preſently precipitated, dripping down by the crannies of the ſtone. In ſome places, entering into the

the caverns of the mountain, it gathers in thoſe receptacles, which being once filled, all the reſt overflows; and breaking out by the ſides of the hills, forms ſingle ſprings. Many of theſe run down by the vallies, or guts between the ridges of the mountain, and coming to unite, form little rivulets or brooks; many of theſe meeting in one common valley, and gaining the plain ground, being grown leſs rapid, become a river: and many of theſe uniting, make ſuch vaſt bodies of water as the Rhine, the Rhone, and the Danube.

There is ſtill a third part, which falls upon the lower grounds, and furniſhes plants with their wonted ſupply. But the circulation does not reſt even here; for it is again exhaled into vapour by the action of the ſun; and again returned to that great maſs of waters whence it firſt aroſe. This, adds Doctor Halley, ſeems the moſt reaſonable hypotheſis; and much more likely to be true, than that of thoſe who derive all ſprings from the filtering of the ſea waters through certain imaginary tubes or paſſages within the earth; ſince it is well known, that the greateſt rivers have their moſt copious fountains the moſt remote from the ſea *.

This ſeems the moſt adopted opinion; and yet, after all, it is ſtill preſſed with great

* Phil. Tranſ. vol. ii. p. 128.

diffi-

difficulties; and there is ſtill room to look out for a better theory. The perpetuity of many ſprings, which always yield the ſame quantity when the leaſt rain or vapour is afforded, as well as when the greateſt, is a ſtrong objection. Derham * mentions a ſpring at Upminſter, which he could never perceive by his eye to be diminiſhed, in the greateſt droughts, even when all the ponds in the country, as well as an adjoining brook, have been dry for ſeveral months together. In the rainy ſeaſons alſo, it was never overflowed; except ſometimes, perhaps, for an hour or ſo, upon the immiſſion of the external rains. He, therefore, juſtly enough concludes, that had this ſpring its origin from rain or vapour, there would be found an encreaſe or decreaſe of its water, correſponding to the cauſes of its production.

Thus the reader, after having been toſſed from one hypotheſis to another, muſt at laſt be contented to ſettle in conſcious ignorance. All that has been written upon this ſubject, affords him rather ſomething to ſay, than ſomething to think; ſomething rather for others than for himſelf. Varenius, indeed, although he is at a loſs for the origin of rivers, is by no means ſo as to their formation. He is pretty poſitive that all rivers are arti-

* Derham Phyſico Theol.

ficial.

ficial. He boldly aſſerts, that their channels have been originally formed by the induſtry of man. His reaſons are, that when a new ſpring breaks forth, the water does not make itſelf a new channel, but ſpreads over the adjacent land. Thus, ſays he, men are obliged to direct its courſe; or, otherwiſe, Nature would never have found one. He enumerates many rivers, that are certainly known, from hiſtory, to have been dug by men. He alledges, that no ſalt-water rivers are found, becauſe men did not want ſalt-water; and as for ſalt, that was procurable at a leſs expence than digging a river for it. However, it coſts a ſpeculative man but a ſmall expence of thinking to form ſuch an hypotheſis. It may, perhaps, engroſs the reader's patience to detain him longer upon it.

Nevertheleſs, though philoſophy be thus ignorant, as to the production of rivers, yet the laws of their motion, and the nature of their currents, have been very well explained. The Italians have particularly diſtinguiſhed themſelves in this reſpect; and it is chiefly to them that we are indebted for the improvement*.

All rivers have their ſource either in mountains, or elevated lakes; and it is in their

* S. Guglielmini della Natura de Fiumi. Paſſim.

deſcent

deſcent from theſe, that they acquire that velocity which maintains their future current. At firſt their courſe is generally rapid and headlong; but it is retarded in its journey, both by the continual friction againſt its banks, by the many obſtacles it meets to divert its ſtream, and by the plains generally becoming more level as it approaches towards the ſea.

If this acquired velocity be quite ſpent, and the plain through which the river paſſes is entirely level, it will, notwithſtanding, ſtill continue to run from the perpendicular preſſure of the water, which is always in exact proportion to the depth. This perpendicular preſſure is nothing more than the weight of the upper waters preſſing the lower out of their places, and, conſequently, driving them forward, as they cannot recede againſt the ſtream. As this preſſure is greateſt in the deepeſt parts of the river, ſo we generally find the middle of the ſtream moſt rapid; both becauſe it has the greateſt motion thus communicated by the preſſure, and the feweſt obſtructions from the banks on either ſide.

Rivers thus ſet into motion are almoſt always found to make their own beds. Where they find the bed elevated, they wear its ſubſtance away, and depoſit the ſediment in the

the next hollow, ſo as in time to make the bottom of their channels even. On the other hand, the water is continually gnawing and eating away the banks on each ſide; and this with more force as the current happens to ſtrike more directly againſt them. By this means, it always has a tendency to render them more ſtrait and parallel to its own courſe. Thus it continues to rectify its banks, and enlarge its bed; and, conſequently, to diminiſh the force of its ſtream, till there becomes an equilibrium between the force of the water, and the reſiſtance of its banks, upon which both will remain without any further mutation. And it is happy for man that bounds are thus put to the eroſion of the earth by water; and that we find all rivers only dig and widen themſelves but to a certain degree *.

In thoſe plains † and large vallies where great rivers flow, the bed of the river is uſually lower than any part of the valley. But it often happens, that the ſurface of the water is higher than many of the grounds that are adjacent to the banks of the ſtream. If, after inundations, we take a view of ſome rivers, we ſhall find their banks appear above water, at a time that all the adjacent valley

* Guglielmini della Natura de Fiumi. Paſſim. † Buffon. De Fleuves. Paſſim, vol ii.

is

is overflown. This proceeds from the frequent depoſition of mud, and ſuch like ſubſtances, upon the banks, by the rivers frequently overflowing; and thus, by degrees, they become elevated above the plain; and the water is often ſeen higher alſo.

Rivers, as every body has ſeen, are always broadeſt at the mouth; and grow narrower towards their ſource. But what is leſs known, and probably more deſerving curioſity, is, that they run in a more direct channel as they immediately leave their ſources; and that their ſinuoſities and turnings become more numerous as they proceed. It is a certain ſign among the ſavages of North America, that they are near the ſea when they find the rivers winding, and every now and then changing their direction. And this is even now become an indication to the Europeans themſelves, in their journies through thoſe trackleſs foreſts. As thoſe ſinuoſities, therefore, encreaſe as the river approaches the ſea, it is not to be wondered at, that they ſometimes divide, and thus diſembogue by different channels. The Danube diſembogues into the Euxine by ſeven mouths; the Nile, by the ſame number; and the Wolga, by ſeventy.

The

The currents * of rivers are to be eſtimated very differently from the manner in which thoſe writers who have given us mathematical theories on this ſubject, repreſent them. They found their calculations upon the ſurface, being a perfect plain, from one bank to the other: but this is not the actual ſtate of Nature; for rivers, in general, riſe in the middle; and this convexity is greateſt in proportion as the rapidity of the ſtream is greater. Any perſon, to be convinced of this, need only lay his eye as nearly as he can on a level with the ſtream, and looking acroſs to the oppoſite bank, he will perceive the river in the midſt to be elevated conſiderably above what it is at the edges. This riſing, in ſome rivers, is often found to be three feet high; and is ever encreaſed, in proportion to the rapidity of the ſtream. In this caſe, the water in the midſt of the current loſes a part of its weight, from the velocity of its motion; while that at the ſides, for the contrary reaſon, ſinks lower. It ſometimes, however, happens, that this appearance is reverſed; for when tides are found to flow up with violence againſt the natural current of the water, the greateſt rapidity is then found at the ſides of the river, as the

* Buffon. De Fleuves. Paſſim, vol. ii.

water

water there leaſt reſiſts the influx from the ſea. On thoſe occaſions, therefore, the river preſents a concave rather than a convex ſurface: and, as in the former caſe, the middle waters roſe in a ridge; in this caſe, they ſink in a furrow.

The ſtream in all rivers is more rapid in proportion as its channel is diminiſhed. For inſtance, it will be much ſwifter where it is ten yards broad, than where it is twenty; for the force behind ſtill puſhing the water forward, when it comes to the narrow part, it muſt make up by velocity what it wants in room.

It often happens that the ſtream of a river is oppoſed by one of its jutting banks, by an iſland in the midſt, the arches of a bridge, or ſome ſuch obſtacle. This produces, not unfrequently, a back current; and the water having paſt the arch with great velocity, puſhes the water on each ſide of its direct current. This produces a ſide current, tending to the bank; and not unfrequently a whirlpool; in which a large body of waters are circulated in a kind of cavity, ſinking down in the middle. The central point of the whirlpool is always loweſt, becauſe it has the leaſt motion: the other parts are ſupported, in ſome meaſure, by the violence of theirs; and, conſequently, riſe higher as their motion

is greater; ſo that towards the extremity of the whirlpool muſt be higher than towards the center.

If the ſtream of a river be ſtopped at the ſurface, and yet be free below; as for inſtance, if it be laid over by a bridge of boats, there will then be a double current; the water at the ſurface will flow back, while that at the bottom will proceed with encreaſed velocity. It often happens that the current at the bottom is ſwifter than at the top, when, upon violent land-floods, the weight of waters towards the ſource, preſſes the waters at the bottom, before it has had time to communicate its motion to the ſurface. However, in all other caſes, the ſurface of the ſtream is ſwifter than the bottom, as it is not retarded by rubbing over the bed of the river.

It might be ſuppoſed that bridges, dams, and other obſtacles in the current of a river, would retard its total velocity. But the difference they make is very inconſiderable. The water, by theſe ſtoppages, gets an elevation above the object; which, when it has ſurmounted, it gives a velocity that recompenſes the former delay. Iſlands and turnings alſo retard the courſe of the ſtream but very inconſiderably; any cauſe which diminiſhes the quantity of the water, moſt ſenſibly diminiſhes the force and the velocity of the ſtream.

An

An encreaſe * of water in the bed of the river, always encreaſes its rapidity; except in caſes of inundation. The inſtant the river has overflowed its banks, the velocity of its current is always turned that way, and the inundation is perceived to continue for ſome days; which it would not otherwiſe do, if, as ſoon as the cauſe was diſcontinued, it acquired its former rapidity.

A violent ſtorm, that ſets directly up againſt the courſe of the ſtream, will always retard, and ſometimes entirely ſtop its courſe. I have ſeen an inſtance of this, when the bed of a large river was left entirely dry for ſome hours, and fiſh were caught among the ſtones at the bottom.

Inundations are generally greater towards the ſource of rivers, than farther down; becauſe the current is generally ſwifter below than above; and that for the reaſons already aſſigned.

A little river † may be received into a large one, without augmenting either its width or depth. This, which at firſt view ſeems a paradox, is yet very eaſily accounted for. The little river, in this caſe, only goes towards encreaſing the ſwiftneſs of the larger, and putting its dormant waters into motion.

* Buffon, vol. ii. p. 62. † Guglielmini, ibid.

In

In this manner, the Venetian branch of the Po was puſhed on by the Ferareſe branch and that of Panaro, without any enlargement of its breadth or depth from theſe acceſſions.

A river tending to enter another, either perpendicularly, or in an oppoſite direction, will be diverted, by degrees, from that direction; and be obliged to make itſelf a more favourable entrance downward, and more conſpiring with the ſtream of the former.

The union of two rivers into one, makes it flow the ſwifter; ſince the ſame quantity of water, inſtead of rubbing againſt four ſhores, now only rubs againſt two. And, beſides, the current being deeper, becomes of conſequence more fitted for motion.

With reſpect to the places from whence rivers proceed, it may be taken for a general rule, that the largeſt * and higheſt mountains ſupply the greateſt and moſt extenſive rivers. It may alſo be remarked, in whatever direction the ridge of the mountain runs, the river takes an oppoſite courſe. If the mountain, for inſtance, ſtretches from north to ſouth, the river runs from eaſt to weſt; and ſo contrariwiſe. Theſe are ſome of the moſt generally received opinions with regard to the courſe of rivers; however, they are liable to

* Doctor Halley.

many

many exceptions; and nothing but an actual knowledge of each particular river can furniſh us with an exact theory of its current.

The largeſt rivers of Europe are, firſt, the Wolga, which is about ſix hundred and fifty leagues in length, extending from Reſchow to Aſtrachan. It is remarkable of this river, that it abounds with water during the ſummer months of May and June; but all the reſt of the year is ſo ſhallow as ſcarce to cover its bottom, or allow a paſſage for loaded veſſels that trade up its ſtream. It was up this river that the Engliſh attempted a trade into Perſia, in which they were ſo unhappily diſappointed, in the year 1741. The next in order is the Danube. The courſe of this is about four hundred and fifty leagues, from the mountains of Switzerland to the Black Sea. It is ſo deep between Buda and Belgrade, that the Turks and Chriſtians have fleets of men of war upon it; which frequently engaged, during the laſt war between the Ottomans and the Auſtrians: however, it is unnavigable further down, by reaſon of its cataracts, which prevent its commerce into the Black Sea. The Don, or Tanais, which is four hundred leagues from the ſource of that branch of it called the Soſna, to its mouth in the Euxine ſea. In one part of its courſe, it approaches near the Wolga;

and Peter the Great had actually begun a canal, by which he intended joining thoſe two rivers; which he did not live to finiſh. The Nieper, or Boriſthenes, which riſes in the middle of Muſcovy, and runs a courſe of three hundred and fifty leagues, to empty itſelf into the Black Sea. The Old Coſſacks inhabit the banks and iſlands of this river; and frequently croſs the Black Sea, to plunder the maritime places on the coaſts of Turky. The Dwina; which takes its riſe in a province of the ſame name in Ruſſia, then runs a courſe of three hundred leagues, and diſembogues into the White Sea, a little below Archangel.

The largeſt rivers of Aſia are, the Hoanho, in China, which is eight hundred and fifty leagues in length, computing from its ſource at Raja Ribron, to its mouth in the Gulph of Changi. The Jeniſca of Tartary, about eight hundred leagues in length, from the Lake Selinga, to the Icy Sea. This river is, by ſome, ſuppoſed to ſupply moſt of that great quantity of drift wood which is ſeen floating in the ſeas, near the Artic circle. The Oby, of five hundred leagues, running from the lake of Kila into the Northern ſea. The Amour, in Eaſtern Tartary, whoſe courſe is about five hundred and ſeventy-five leagues, from its ſource to its entrance

into

into the ſea of Kamtſkatka. The Kiam, in China, five hundred and fifty leagues in length. The Ganges, one of the moſt noted rivers in the world, and about as long as the former. It riſes in the mountains which ſeparate India from Tartary; and running through the dominions of the Great Mogul, diſcharges itſelf by ſeveral mouths into the bay of Bengal. It is not only eſteemed by the Indians for the depth, and pureneſs of its ſtream, but for a ſuppoſed ſanctity which they believe to be in its waters. It is viſited annually by ſeveral hundred thouſand pilgrims, who pay their devotions to the river as to a god; for ſavage ſimplicity is always known to miſtake the bleſſings of the Deity, for the Deity himſelf. They carry their dying friends from diſtant countries, to expire on its banks; and to be buried in its ſtream. The water is loweſt in April or May; but the rains beginning to fall ſoon after, the flat country is overflowed for ſeveral miles, till about the end of September; the waters then begin to retire, leaving a prolific ſediment behind, that enriches the ſoil, and, in a few days time, gives a luxuriance to vegetation, beyond what can be conceived by an European. Next to this may be reckoned the ſtill more celebrated river Euphrates. This riſes from two ſources, northward of

the city Erzerum, in Turcomania; and unites about three days journey below the ſame; from whence, after performing a courſe of five hundred leagues, it falls into the Gulph of Perſia, fifty miles below the city of Baſſora in Arabia. The river Indus is extended from its ſource to its diſcharge into the Arabian ſea, four hundred leagues.

The largeſt rivers of Africa are, the Senegal, which runs a courſe of not leſs than eleven hundred leagues, comprehending the Niger, which ſome have ſuppoſed to fall into it. However, later accounts ſeem to affirm that the Niger is loſt in the ſands, about three hundred miles up from the weſtern coaſts of Africa. Be this as it may, the Senegal is well known to be navigable for more than three hundred leagues up the country; and how much higher it may reach is not yet diſcovered, as the dreadful fatality of the inland parts of Africa, not only deter curioſity, but even avarice, which is a much ſtronger paſſion. At the end of laſt war, of fifty Engliſh men that were ſent to the factory at Galam, a place taken from the French, and nine hundred miles up the river, only one returned to tell the fate of his companions, who were killed by the climate. The celebrated river Nile is ſaid to be nine hundred and ſeventy leagues, from its

ſource

ſource among the mountains of the Moon, in Upper Æthiopia, to its opening into the Mediterranean ſea. The ſources of this river were conſidered as inſcrutable by the ancients; and the cauſes of its periodical inundation were equally unknown. They have both been aſcertained by the miſſionaries who have travelled into the interior parts of Æthiopia. The Nile takes its riſe in the kingdom of Gojam*, from a ſmall aperture on the top of a mountain, which, though not above a foot and an half over, yet was unfathomable. This fountain, when arrived at the foot of the mountain, expands into a river; and, being joined by others, forms a lake thirty leagues long, and as many broad; from this, its channel, in ſome meaſure, winds back to the country where it firſt began; from thence, precipitating by frightful cataracts, it travels through a variety of deſart regions, equally formidable, ſuch as Amhara, Olaca, Damot, and Xaoa. Upon its arrival in the kingdom of Upper Egypt, it runs through a rocky channel, which ſome late travellers have miſtaken for its cataracts. In the beginning of its courſe, it receives many leſſer rivers into it; and Pliny was miſtaken, in ſaying that it received none. In the beginning alſo of its courſe, it

* Kircher, Mund. Subt. vol. ii. p. 72.

has

has many windings; but, for above three hundred leagues from the ſea, it runs in a direct line. Its annual overflowings ariſe from a very obvious cauſe, which is almoſt univerſal with all the great rivers that take their ſource near the Line. The rainy ſeaſon, which is periodical in thoſe climates, flood the rivers; and as this always happens in our ſummer, ſo the Nile is at that time overflown. From theſe inundations, the inhabitants of Egypt derive happineſs and plenty; and, when the river does not riſe to its accuſtomed heights, they prepare for an indifferent harveſt. It begins to overflow about the ſeventeenth of June; it generally continues to augment for forty days, and decreaſes in about as many more. This time of encreaſe and decreaſe, however, is much more inconſiderable now than it was among the ancients. Herodotus informs us, that it was an hundred days riſing, and as many falling; which ſhews that the inundation was much greater at that time than at preſent. Mr. Buffon * has aſcribed the preſent diminution, as well to the leſſening of the mountains of the Moon, by their ſubſtance having ſo long been waſhed down with the ſtream, as to the riſing of the earth in Egypt, that has for ſo many ages received

* Buffon, vol. ii. p. 82.

this

this extraneous ſupply. But we do not find, by the buildings that have remained ſince the times of the ancients, that the earth is much raiſed ſince then. Beſides the Nile in Africa, we may reckon the Zara, and the Coanza, from the greatneſs of whoſe openings into the ſea, and the rapidity of whoſe ſtreams, we form an eſtimate of the great diſtance from whence they come. Their courſes, however, are ſpent in watering deſerts and ſavage countries, whoſe poverty or fierceneſs have kept ſtrangers away.

But of all parts of the world, America, as it exhibits the moſt lofty mountains, ſo alſo it ſupplies the largeſt rivers. The foremoſt of theſe is the great river Amazons, which, from its ſource in the lake of Lauricocha, to its diſcharge into the Weſtern Ocean, performs a courſe of more than twelve hundred leagues*. The breadth and depth of this river is anſwerable to its vaſt length; and, where its width is moſt contracted, its depth is augmented in proportion. So great is the body of its waters, that other rivers, though before the objects of admiration, themſelves are loſt in its boſom. It proceeds, after their junction, with its uſual appearance, without any viſible change in its breadth or rapidity; and, if we may ſo expreſs it, remains great

* Ulloa, vol. i. p. 388.

without

without oſtentation. In ſome places it diſplays its whole magnificence, dividing into ſeveral large branches, and encompaſſing a multitude of iſlands; and, at length, diſcharging itſelf into the ocean, by a channel of an hundred and fifty miles broad. Another river, that may almoſt rival the former, is the St. Lawrence, in Canada, which riſing in the lake Aſſiniboils, paſſes from one lake to another, from Criſtinaux to Alempigo; from thence to lake Superior; thence to the lake Hurons; to lake Erie; to lake Ontario; and, at laſt, after a courſe of nine hundred leagues, pours their collected waters into the Atlantic ocean. The river Miſſiſippi is of more than ſeven hundred leagues in length, beginning at its ſource near the lake Aſſiniboils, and ending at its opening into the Gulph of Mexico. The river Plate runs a length of more than eight hundred leagues from its ſource in the river Parana, to its mouth. The river Oroonoko is ſeven hundred and fifty-five leagues in length, from its ſource near Paſto, to its diſcharge into the Atlantic ocean.

Such is the amazing length of our greateſt rivers; and even in ſome of theſe, the moſt remote ſources very probably yet continue unknown. In fact, if we conſider the number of rivers which they receive, and the little

acquain-

acquaintance we have with the regions through which they run, it is not to be wondered at that geographers are divided concerning the ſources of moſt of them. As among a number of roots by which nouriſhment is conveyed to a ſtately tree, it is difficult to determine preciſely that by which the tree is chiefly ſupplied; ſo among the many branches of a great river, it is equally difficult to tell which is the original. Hence it may eaſily happen, that a ſmaller branch is taken for the capital ſtream; and its runnings are purſued, and delineated, in prejudice of ſome other branch that better deſerved the name and the deſcription. In this manner * in Europe, the Danube is known to receive thirty leſſer rivers: the Wolga, thirty-two or thirty-three. In Aſia, the Hohanno receives thirty-five; the Jeniſca above ſixty; the Oby as many; the Amour about forty; the Nanquin receives thirty rivers; the Ganges twenty; and the Euphrates about eleven. In Africa, the Senegal receives more than twenty rivers; the Nile receives not one for five hundred leagues upwards, and then only twelve or thirteen. In America, the river Amazons receives above ſixty, and thoſe very conſiderable; the river St. Lawrence about forty,

* Buffon, vol. ii. p. 74.

counting

counting thoſe which fall into its lakes; the Miſſiſippi receives forty; and the river Plate above fifty.

I mentioned the inundations of the Ganges and the Nile, but almoſt every other great river whoſe ſource lies within the tropics, have their ſtated inundations alſo. The river Pegu has been called, by travellers, the Indian Nile, becauſe of the ſimilar overflowings of its ſtream: this it does to an extent of thirty leagues on each ſide; and ſo fertilizes the ſoil, that the inhabitants ſend great quantities of rice into other countries, and have ſtill abundance for their own conſumption. The river Senegal has likewiſe its inundations, which cover the whole flat country of Negroland, beginning and ending much about the ſame time with thoſe of the Nile; as, in fact, both rivers riſe from the ſame mountains. But the difference between the effects of the inundations in each river, is remarkable: in the one, it diſtributes health and plenty; but in the other, diſeaſes, famine, and death. The inhabitants along the torrid coaſts of the Senegal, can receive no benefit from any additional manure the river may carry down to their ſoil, which is, by nature, more than ſufficiently luxuriant; or, even if they could, they have not induſtry to turn it to any advantage. The banks,

banks, therefore, of the rivers, lie uncultivated, overgrown with rank and noxious herbage, and infeſted with thouſands of animals of various malignity. Every new flood only tends to encreaſe the rankneſs of the ſoil, and to provide freſh ſhelter for the creatures that infeſt it. If the flood continues but a few days longer than uſual, the improvident inhabitants, who are driven up into the higher grounds, begin to want proviſions, and a famine enſues. When the river begins to return into its channel, the humidity and heat of the air are equally fatal; and the carcaſes of infinite numbers of animals, ſwept away by the inundation, putrefying in the ſun, produce a ſtench that is almoſt inſupportable. But even the luxuriance of the vegetation itſelf, becomes a nuiſance. I have been aſſured, by perſons of veracity that have been up the river Senegal, that there are ſome plants that grow along the coaſt, the ſmell of which is ſo powerful, that it is hardly to be endured. It is certain, that all the ſailors and ſoldiers who have been at any of our factories there, aſcribe the unwholeſomeneſs of the voyage up the ſtream, to the vegetable vapour. However this be, the inundations of the rivers in this wretched part of the globe, contribute ſcarce any advantage, if we except

cept the beauty of the proſpects which they afford. Theſe, indeed, are finiſhed up beyond the utmoſt reach of art: a ſpacious glaſſy river, with its banks here and there fringed to the very ſurface by the mangrove-tree, that grows down into the water, preſents itſelf to view. Lofty foreſts of various colours, with openings between, carpeted with green plants, and the moſt gaudy flowers; beaſts and animals, of various kinds, that ſtand upon the banks of the river, and, with a ſort of wild curioſity, ſurvey the mariners as they paſs, contribute to heighten the ſcene. This is the ſketch of an African proſpect; which delights the eye, even while it deſtroys the conſtitution.

Beſide theſe annually periodical inundations, there are many rivers that overflow at much ſhorter intervals. Thus moſt of thoſe in Peru and Chili have ſcarce any motion by night; but upon the appearance of the morning ſun, they reſume their former rapidity: this proceeds from the mountain ſnows, which melting with the heat, encreaſe the ſtream, and continue to drive on the current while the ſun continues to diſſolve them. Some rivers alſo flow with an even ſteady current, from their ſource to the ſea; others flow with greater rapidity, their ſtream being poured down in a cataract, or ſwallowed by the ſands, before they reach the ſea.

The

The rivers of thoſe countries that have been leaſt inhabited, are uſually more rocky, uneven, and broken into water-falls or cataracts, than thoſe where the induſtry of man has been more prevalent. Wherever man comes, nature puts on a milder appearance: the terrible and the ſublime, are exchanged for the gentle and the uſeful; the cataract is ſloped away into a placid ſtream; and the banks become more ſmooth and even *. It muſt have required ages to render the Rhone or the Loire navigable; their beds muſt have been cleaned and directed; their inequalities removed; and, by a long courſe of induſtry, nature muſt have been taught to conſpire with the deſires of her controller. Every one's experience muſt have ſupplied inſtances of rivers thus being made to flow more evenly, and more beneficially to mankind; but there are ſome whoſe currents are ſo rapid, and falls ſo precipitate, that no art can obviate; and that muſt for ever remain as amazing inſtances of incorrigible nature.

Of this kind are the cataracts of the Rhine; one of which I have ſeen exhibit a very ſtrange appearance; it was that at Schathauſen, which was frozen quite acroſs, and the water ſtood in columns where the cataract had formerly fallen. The Nile, as was ſaid,

* Buffon, vol. ii. 90.

has

has its cataracts. The river Vologda, in Ruſſia, has two. The river Zara, in Africa, has one near its ſource. The river Velino, in Italy, has a cataract of above an hundred and fifty feet perpendicular. Near the city Gottenburgh *, in Sweden, the river there ruſhes down from a prodigious high precipice, into a deep pit, with a terrible noiſe, and ſuch dreadful force, that thoſe trees deſigned for the maſts of ſhips, which are floated down the river, uſually are turned upſide down in their fall, and often are ſhattered to pieces, by being daſhed againſt the ſurface of the water in the pit; this occurs if the maſts fall ſideways upon the water; but if they fall endways, they dive ſo far under water, that they diſappear for a quarter of an hour, or more: the pit into which they are thus plunged, has been often ſounded with a line of ſome hundred fathoms long, but no ground has been found hitherto. There is alſo a cataract at Powerſcourt, in Ireland, in which, if I am rightly informed, the water falls three hundred feet perpendicular; which is a greater deſcent than that of any other cataract in any part of the world. There is a cataract in Albany, in the province of New York, which pours its ſtream fifty feet perpendicular. But of all the cataracts in the

* Phil. Tranſ. vol. ii. p. 325.

world,

world, that of Niagara, in Canada, if we conſider the great body of water that falls, muſt be allowed to be the greateſt, and the moſt aſtoniſhing.

This amazing fall of water is made by the river St. Lawrence, in its paſſage from the lake Erie into the lake Ontario. We have already ſaid that St. Lawrence is one of the largeſt rivers in the world; and yet the whole of its waters are here poured down, by a fall of an hundred and fifty feet perpendicular. It is not eaſy to bring the imagination to correſpond with the greatneſs of the ſcene; a river extremely deep and rapid, and that ſerves to drain the waters of almoſt all North America into the Atlantic ocean, is here poured precipitately down a ledge of rocks, that riſe, like a wall, acroſs the whole bed of its ſtream. The width of the river, a little above, is near three quarters of a mile broad; and the rocks, where it grows narrower, are four hundred yards over. Their direction is not ſtreight acroſs, but hollowing inwards like an horſe-ſhoe; ſo that the cataract, which bends to the ſhape of the obſtacle, rounding inwards, preſents a kind of theatre the moſt tremendous in nature. Juſt in the middle of this circular wall of waters, a little iſland, that has braved the fury of the current,

preſents

preſents one of its points, and divides the ſtream at top into two; but it unites again long before it has got to the bottom. The noiſe of the fall is heard at ſeveral leagues diſtance; and the fury of the waters at the bottom of their fall, is inconceivable. The daſhing produces a miſt that riſes to the very clouds; and that produces a moſt beautiful rainbow, when the ſun ſhines. It may eaſily be conceived, that ſuch a cataract quite deſtroys the navigation of the ſtream; and yet ſome Indian canoes, as it is ſaid, have been known to venture down it with ſafety.

Of thoſe rivers that loſe themſelves in the ſands, or are ſwallowed up by chaſms in the earth, we have various information. What we are told by the ancients, of the river Alpheus, in Arcadia, that ſinks into the ground, and riſes again near Syracuſe, in Sicily, where it takes the name of Arethuſa, is rather more known than credited. But we have better information with reſpect to the river Tigris being loſt in this manner under Mount Taurus; of the Guadalquiver, in Spain, being buried in the ſands; of the river Greatah, in Yorkſhire, running underground, and riſing again; and even of the great Rhine itſelf, a part of which is no doubt loſt in the ſands, a little above Leyden. But it ought to be obſerved of this river, that by much the greateſt

part

part arrives at the ocean. For, although the ancient channel which fell into the ſea, a little to the weſt of that city, be now entirely choaked up, yet there are ſtill a number of ſmall canals, that carry a great body of waters to the ſea: and, beſides, it has alſo two very large openings, the Lech, and the Wal, below Rotterdam, by which it empties itſelf abundantly.

Be this as it will, nothing is more common in ſultry and ſandy deſerts, than rivers being thus either loſt in the ſands, or entirely dried up by the ſun. And hence we ſee, that under the Line, the ſmall rivers are but few; for ſuch little ſtreams as are common in Europe, and which with us receive the name of rivers, would quickly evaporate, in thoſe parching and extenſive deſerts. It is even confidently aſſerted, that the great river Niger itſelf is thus loſt before it reaches the ocean; and that its ſuppoſed mouths, the Gambia, and the Senegal, are diſtinct rivers, that come a vaſt way from the interior parts of the country. It appears, therefore, that the rivers under the Line are large; but it is otherwiſe at the Poles *, where they muſt neceſſarily be ſmall. In that deſolate region, as the mountains are covered with per-

* Krantz's Hiſtory of Greenland, vol. i. p. 41.

petual ice, which melts but little, or not at all, the ſprings and rivulets are furniſhed with a very ſmall ſupply. Here, therefore, men and beaſts would periſh, and die for thirſt, if Providence had not ordered, that in the hardeſt winter, thaws ſhould intervene, which depoſit a ſmall quantity of ſnow-water in pools under the ice; and from this ſource the wretched inhabitants drain a ſcanty beverage.

Thus, whatever quarter of the globe we turn to, we ſhall find new reaſons to be ſatisfied with that part of it in which we ourſelves reſide. Our rivers furniſh all the plenty of the African ſtream, without its inundation; they have all the coolneſs of the Polar rivulet, with a more conſtant ſupply; they may want the terrible magnificence of huge cataracts, or extenſive lakes, but they are more navigable, and more tranſparent; though leſs deep and rapid than the rivers of the torrid zone, they are more manageable, and only wait the will of man to take their direction. The rivers of the torrid zone, like the monarchs of the country, rule with deſpotic tyranny, profuſe in their bounties, and ungovernable in their rage. The rivers of Europe, like their kings, are the friends, and not the oppreſſors of the people; bounded by known limits, abridged in the power of doing

doing ill, directed by human ſagacity, and only at freedom to diſtribute happineſs and plenty.

CHAP. XV.

Of the Ocean in general; and of its Saltneſs.

IF we look upon a map of the world, we ſhall find that the ocean occupies conſiderably more of the globe, than the land is found to do. This immenſe body of waters is diffuſed round both the Old and New Continent, to the ſouth; and may ſurround them alſo to the north, for what we know, but the ice in thoſe regions has ſtopped our enquiries. Although the ocean, properly ſpeaking, is but one extenſive ſheet of waters, continued over every part of the globe, without interruption, and although no part of it is divided from the reſt, yet geographers have diſtinguiſhed it by different names; as the Atlantic or Weſtern Ocean, the Northern Ocean, the Southern Ocean, the Pacific Ocean, and the Indian Ocean. Others have divided it differently, and given other names; as the Frozen Ocean, the Inferior Ocean, or the American Ocean. But all theſe being arbitrary diſtinctions, and not of Nature's making, the naturaliſt may conſider them with indifference.

In this vaſt receptacle, almoſt all the rivers of the earth ultimately terminate; nor do ſuch great ſupplies ſeem to encreaſe its ſtores; for it is neither apparently ſwollen by their tribute, nor diminiſhed by their failure; it ſtill continues the ſame. Indeed, what is the quantity of water of all the rivers and lakes in the world, compared to that contained in this great receptacle*? If we ſhould offer to make a rude eſtimate, we ſhall find that all the rivers in the world, flowing into the bed of the ſea, with a continuance of their preſent ſtores, would take up at leaſt eight hundred years to fill it to its preſent height. For, ſuppoſing the ſea to be eighty-five millions of ſquare miles, in extent, and a quarter of a mile, upon an average, in depth, this, upon calculation, will give above twenty-one millions of cubic miles of water, as the contents of the whole ocean. Now, to eſtimate the quantity of water which all the rivers ſupply, take any one of them; the Po, for inſtance, the quantity of whoſe diſcharge into the ſea, is known to be one cubic mile of water in twenty-ſix days. Now it will be found, upon a rude computation, from the quantity of ground the Po, with its influent ſtreams, covers, that all the rivers of the world furniſh about two

* Buffon, vol. ii. p. 70.

thou-

thouſand times that quantity of water. In the ſpace of a year, therefore, they will have diſcharged into the ſea about twenty-ſix thouſand cubic miles of water; and not till eight hundred years, will they have diſcharged as much water as is contained in the ſea at preſent. I have not troubled the reader with the odd numbers, leſt he ſhould imagine I was giving preciſion to a ſubject that is incapable of it.

Thus great is the aſſemblage of waters diffuſed round our habitable globe; and yet, immeaſurable as they ſeem, they are moſtly rendered ſubſervient to the neceſſities and the conveniencies of ſo little a being as man. Nevertheleſs, if it ſhould be aſked whether they be made for him alone, the queſtion is not eaſily reſolved. Some philoſophers have perceived ſo much analogy to man in the formation of the ocean, that they have not heſitated to aſſert its being made for him alone. The diſtribution of land and water *, ſay they, is admirable; the one being laid againſt the other ſo ſkilfully, that there is a juſt equipoiſe of the whole globe. Thus the Northern ocean balances againſt the Southern; and the New Continent is an exact counter-weight to the Old. As to any objection from the ocean's occupying too large a ſhare of the

* Derham Phyſico Theol.

globe,

globe, they contend, that there could not have been a ſmaller ſurface employed to ſupply the earth with a due ſhare of evaporation. On the other hand, ſome take the gloomy ſide of the queſtion; they either magnify * its apparent defects; or aſſert, that † what ſeems defects to us, may be real beauties to ſome wiſer order of beings. They obſerve, that multitudes of animals are concealed in the ocean, and but a ſmall part of them are known; the reſt, therefore, they fail not to ſay, were certainly made for their own benefit, and not for ours. How far either of theſe opinions be juſt, I will not preſume to determine; but of this we are certain, that God has endowed us with abilities to turn this great extent of waters to our own advantage. He has made theſe things, perhaps, for other uſes; but he has given us faculties to convert them to our own. This much agitated queſtion, therefore, ſeems to terminate here. We ſhall never know whether the things of this world have been made for our uſe; but we very well know, that we have been made to enjoy them. Let us then boldly affirm, that the earth, and all its wonders, are ours; ſince we are furniſhed with powers to force them into our ſervice. Man is the lord of all the

* Burnet's Theory. Paſſim. † Pope's Ethic Epiſtles. Paſſim.

ſublu-

ſublunary creation; the howling ſavage, the winding ſerpent, with all the untamable and rebellious offspring of Nature, are deſtroyed in the conteſt, or driven at a diſtance from his habitations. The extenſive and tempeſtuous ocean, inſtead of limiting or dividing his power, only ſerves to aſſiſt his induſtry, and enlarge the ſphere of his enjoyments. Its billows, and its monſters, inſtead of preſenting a ſcene of terror, only call up the courage of this little intrepid being; and the greateſt dangers that man now fears on the deep, is from his fellow creatures. Indeed, when I conſider the human race as Nature has formed them, there is but very little of the habitable globe that ſeems made for them. But when I conſider them as accumulating the experience of ages, in commanding the earth, there is nothing ſo great, or ſo terrible. What a poor contemptible being is the naked ſavage, ſtanding on the beach of the ocean, and trembling at its tumults! How little capable is he of converting its terrors into benefits; or of ſaying, behold an element made wholly for my enjoyment! He conſiders it as an angry deity, and pays it the homage of ſubmiſſion. But it is very different when he has exerciſed his mental powers; when he has learn-

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ed to find his own ſuperiority, and to make it ſubſervient to his commands. It is then that his dignity begins to appear, and that the true Deity is juſtly praiſed for having been mindful of man; for having given him the earth for his habitation, and the ſea for an inheritance.

This power which man has obtained over the ocean, was at firſt enjoyed in common; and none pretended to a right in that element where all ſeemed intruders. The ſea, therefore, was open to all till the time of the emperor Juſtinian. His ſucceſſor Leo granted ſuch as were in poſſeſſion of the ſhore, the ſole right of fiſhing before their reſpective territories. The Thracian Boſphorus was the firſt that was thus appropriated; and from that time it has been the ſtruggle of moſt of the powers of Europe to obtain an excluſive right in this element. The Republic of Venice claims the Adriatic. The Danes are in poſſeſſion of the Baltic. But the Engliſh have a more extenſive claim to the empire of all the ſeas, encompaſſing the kingdoms of England, Scotland, and Ireland; and altho' theſe have been long conteſted, yet they are now conſidered as their indiſputable property. Every one knows that the great power

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of the nation is exerted on this element; and that the inſtant England ceaſes to be ſuperior upon the ocean, its ſafety begins to be precarious.

It is in ſome meaſure owing to our dependance upon the ſea, and to our commerce there, that we are ſo well acquainted with its extent and figure. The bays, gulphs, currents, and ſhallows of the ocean, are much better known and examined than the provinces and kingdoms of the earth itſelf. The hopes of acquiring wealth by commerce, has carried man to much greater lengths than the deſire of gaining information could have done. In conſequence of this, there is ſcarce a ſtrait or an harbour, ſcarce a rock or a quickſand, ſcarce an inflexion of the ſhore, or the jutting of a promontory, that has not been minutely deſcribed. But as theſe preſent very little entertainment to the imagination, or delight to any but thoſe whoſe purſuits are lucrative, they need not be dwelt upon here. While the merchant and the mariner are ſolicitous in deſcribing currents and ſoundings, the naturaliſt is employed in obſerving wonders, though not ſo beneficial, yet to him of a much more important nature. The ſaltneſs of the ſea ſeems to be the foremoſt.

Whence the ſea has derived that peculiar bitteriſh ſaltneſs which we find in it, appears,

pears, by Ariſtotle, to have exerciſed the curioſity of naturaliſts in all ages. He ſuppoſed (and mankind were for ages content with the ſolution) that the ſun continually raiſed dry ſaline exhalations from the earth, and depoſited them upon the ſea; and hence, ſay his followers, the waters of the ſea are more ſalt at top than at bottom. But, unfortunately for this opinion, neither of the facts are true. Sea ſalt is not to be raiſed by the vapours of the ſun; and ſea water is not ſalter at the top than at the bottom. Father Bohours is of opinion that the Creator gave the waters of the ocean their ſaltneſs at the beginning; not only to prevent their corruption, but to enable them to bear greater burthens. But their ſaltneſs does not prevent their corruption; for ſtagnant ſea-water, like freſh, ſoon grows putrid: and, as for their bearing greater burthens, freſh water anſwers all the purpoſes of navigation quite as well. The eſtabliſhed opinion, therefore, is that of Boyle*, who ſuppoſes, "that the ſea's ſaltneſs is ſupplied not only from rocks or maſſes of ſalt at the bottom of the ſea, but alſo from the ſalt which the rains and rivers, and other waters, diſſolve in their paſſage thro' many parts of the earth, and at length carry with them to the ſea." But

* Boyle, vol. iii. p. 221.

as there is a difference in the taſte of rock-ſalt found at land, and that diſſolved in the waters of the ocean, this may be produced by the plenty of nitrous and bituminous bodies that, with the ſalts, are likewiſe waſhed into that great receptacle. Theſe ſubſtances being thus once carried to the ſea, muſt for ever remain there; for they do not riſe by evaporation, ſo as to be returned back from whence they came. Nothing but the freſh waters of the ſea riſe in vapours; and all the ſaltneſs remains behind. From hence it follows, that every year the ſea muſt become more and more ſalt; and this ſpeculation Doctor Halley carries ſo far as to lay down a method of finding out the age of the world by the ſaltneſs of its waters. "For if it be obſerved *," ſays he, "what quantity of ſalt is at preſent contained in a certain weight of water, taken up from the Caſpian Sea, for example, and, after ſome centuries, what greater quantity of ſalt is contained in the ſame weight of water, taken from the ſame place; we may conclude, that in proportion as the ſaltneſs has encreaſed in a certain time, ſo much muſt it have encreaſed before that time; and we may thus, by the rule of proportion, make an eſtimate of the whole time wherein the water would acquire the

* Phil. Tranſ. vol. v. p. 218.

degree

degree of ſaltneſs it ſhould be then poſſeſſed of." All this may be fine; however, an experiment, begun in this century, which is not to be completed till ſome centuries hence, is rather a little mortifying to modern curioſity: and, I am induced to think, the inhabitants round the Caſpian ſea, will not be apt to undertake the enquiry.

This ſaltneſs is found to prevail in every part of the ocean; and as much at the ſurface, as at the bottom. It is alſo found in all thoſe ſeas that communicate with the ocean; but rather in a leſs degree.

The great lakes, likewiſe, that have no outlets nor communication with the ocean, are found to be ſalt; but ſome of them in leſs proportion. On the contrary, all thoſe lakes through which rivers run into the ſea, however extenſive they be, are, notwithſtanding, very freſh: for the rivers do not depoſit their ſalts in the bed of the lake, but carry them, with their currents, into the ocean. Thus the lakes Ontario and Erie, in North America, although for magnitude they may be conſidered as inland ſeas, are, nevertheleſs, freſh water lakes; and kept ſo by the river St. Lawrence, which paſſes through them. But thoſe lakes that have no communication with the ſea, nor any rivers going out, although they be leſs than the former,

former, are, however, always ſalt. Thus, that which goes by the name of the Dead Sea, tho' very ſmall, when compared to thoſe already mentioned, is ſo exceedingly ſalt, that its waters ſeem ſcarce capable of diſſolving any more. The lakes of Mexico, and of Titicaca, in Peru, though of no great extent, are, nevertheleſs ſalt; and both for the ſame reaſon.

Thoſe who are willing to turn all things to the beſt, have not failed to conſider this ſaltneſs of the ſea, as a peculiar bleſſing from Providence, in order to keep ſo great an element ſweet and wholſome. What foundation there may be in the remark, I will not pretend to determine; but we ſhall ſhortly find a much better cauſe for its being kept ſweet, namely by its motion.

On the other hand, there have been many who have conſidered the ſubject in a different light, and have tried every endeavour to make ſalt-water freſh, ſo as to ſupply the wants of mariners in long voyages, or when exhauſted of their ordinary ſtores. At firſt it was ſuppoſed ſimple diſtillation would do; but it was ſoon found that the bitter part of the water ſtill kept mixed. It was then tried by uniting ſalt of Tartar with ſea-water, and diſtilling both: but here the expence was greater than the advantage. Calcined

bones

bones were next thought of; but an hogſhead of calcined bones, carried to ſea, would take up as much room as an hogſhead of water, and was more hard to be obtained. In this ſtate, therefore, have the attempts to ſweeten ſea-water reſted; the chymiſt ſatisfied with the reality of his invention; and the mariner convinced of its being uſeleſs. I cannot, therefore, avoid mentioning a kind of ſuccedaneum which has been lately conceived to anſwer the purpoſes of freſh-water, when mariners are quite exhauſted. It is well known, that perſons who go into a warm bath, come out ſeveral ounces heavier than they went in; their bodies having imbibed a correſpondent quantity of water. This more particularly happens, if they have been previouſly debarred from drinking, or go in with a violent thirſt; which they quickly find quenched, and their ſpirits reſtored. It was ſuppoſed, that in caſe of a total failure of freſh-water at ſea, a warm bath might be made of ſea-water, for the uſe of mariners; and that their pores would thus imbibe the fluid, without any of its ſalts, which would be ſeen to cryſtallize on the ſurface of their bodies. In this manner, it is ſuppoſed, a ſufficient quantity of moiſture may be procured to ſuſtain life, till time or accident furniſh a more copious ſupply.

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But, however this be, the ſaltneſs of the ſea can by no means be conſidered as a principal cauſe in preſerving its waters from putrefaction. The ocean has its currents, like rivers, which circulate its contents round the globe; and theſe may be ſaid to be the great agents that keep it ſweet and wholſome. Its ſaltneſs alone would by no means anſwer this purpoſe: and ſome have even imagined, that the various ſubſtances with which it is mixed, rather tend to promote putreſcence than impede it. Sir Robert Hawkins, one of our moſt enlightened navigators, gives the following account of a calm, in which the ſea continuing for ſome time without motion, began to aſſume a very formidable appearance. "Were it not," ſays he, "for the moving of the ſea, by the force of winds, tides, and currents, it would corrupt all the world. The experiment of this I ſaw in the year 1590, lying with a fleet about the iſlands of Azores, almoſt ſix months; the greateſt part of which time we were becalmed. Upon which all the ſea became ſo repleniſhed with ſeveral ſorts of gellies, and forms of ſerpents, adders, and ſnakes, as ſeemed wonderful: ſome green, ſome black, ſome yellow, ſome white, ſome of divers colours, and many of them had life; and ſome there were an yard and an half, and two yards long; which had I not ſeen, I could hardly

hardly have believed. And hereof are witneſſes all the company of the ſhips which were then preſent: ſo that hardly a man could draw a bucket of water clear of ſome corruption. In which voyage, towards the end thereof, many of every ſhip fell ſick, and began to die apace. But the ſpeedy paſſage into our country, was a remedy to the craz'd, and a preſervative for thoſe that were not touched."

This ſhews, abundantly, how little the ſea's ſaltneſs was capable of preſerving it from putrefaction: but to put the matter beyond all doubt, Mr. Boyle kept a quantity of ſea-water, taken up in the Engliſh channel, for ſome time barrelled up; and, in the ſpace of a few weeks, it began to acquire a fœtid ſmell*: He was alſo aſſured, by one of his acquaintance who was becalmed for twelve or fourteen days in the Indian ſea, that the water, for want of motion, began to ſtink; and that had it continued much longer, the ſtench would probably have poiſoned him. It is the motion, therefore, and not the ſaltneſs of the ſea, that preſerves it in its preſent ſtate of ſalubrity; and this, very probably, by daſhing and breaking in pieces the rudiments, if I may ſo call them, of the various animals that would otherwiſe breed there, and putrefy.

* Boyle, vol. iii. p. 222.

There

There are ſome advantages, however, which are derived from the ſaltneſs of the ſea. Its waters being evaporated, furniſh that ſalt which is uſed for domeſtic purpoſes; and, although in ſome places it is made from ſprings, and, in others, dug out of mines, yet the greateſt quantity is made only from the ſea. That which is called bay-ſalt, (from its coming to us by the Bay of Biſcay) is a ſtronger kind, made by evaporation in the ſun: that called common ſalt, is evaporated in pans over the fire, and is of a much inferior quality to the former.

Another benefit ariſing from the quantity of ſalt diſſolved in the ſea, is, that it thus becomes heavier, and, conſequently, more buoyant. Mr. Boyle, who examined the difference between ſea-water and freſh, found that the former appeared to be about a forty-fifth part heavier than the latter. Thoſe, alſo, who have had opportunities of bathing in the ſea, pretend to have experienced a much greater eaſe in ſwimming there, than in freſh water. However, as we ſee they have only a forty-fifth part more of their weight ſuſtained by it, I am apt to doubt whether ſo minute a difference can be practically perceivable. Be this as it may, as ſea-water alters in its weight from freſh, ſo it is found alſo to differ from itſelf in different parts of the ocean. In general, it

is perceived to be heavier, and, conſequently, ſalter, the nearer we approach the Line*.

But there is an advantage ariſing from the ſaltneſs of the waters of the ſea, much greater than what has been yet mentioned; which is, that their congelation is thus retarded. Some, indeed, have gone ſo far as to ſay, that † ſea-water never freezes: but this is an aſſertion contradicted by experience. However it is certain that it requires a much greater degree of cold to freeze it, than freſh water; ſo that, while rivers and ſprings are ſeen converted into one ſolid body of ice, the ſea is always fit for navigation, and no way affected by the coldneſs of the ſevereſt winter. It is, therefore, one of the greateſt bleſſings we derive from this element, that when at land all the ſtores of Nature are locked up from us, we find the ſea ever open to our neceſſities, and patient of the hand of induſtry.

But it muſt not be ſuppoſed, becauſe in our temperate climate we never ſee the ſea frozen, that it is in the ſame manner open in every part of it. A very little acquaintance with the accounts of mariners, muſt have informed us, that at the polar regions it is embarraſſed with mountains, and mov-

* Phil. Tranſ. vol. ii. p. 297. † Macrobius.

ing

ing ſheets of ice, that often render it impaſſable. Theſe tremendous floats are of different magnitudes; ſometimes riſing more than a thouſand feet above the ſurface of the water *; ſometimes diffuſed into plains of above two hundred leagues in length, and, in many parts, ſixty or eighty broad. They are uſually divided by fiſſures; one piece following another ſo cloſe, that a perſon may ſtep from one to the other. Sometimes mountains are ſeen riſing amidſt theſe plains, and preſenting the appearance of a variegated landſcape, with hills and valleys, houſes, churches, and towers. Theſe are appearances in which all naturaliſts are agreed; but the great conteſt is reſpecting their formation. Mr. Buffon aſſerts †, that they are formed from freſh water alone; which congealing at the mouths of great rivers, accumulate thoſe huge maſſes that diſturb navigation. However, this great naturaliſt ſeems not to have been aware that there are two ſorts of ice floating in theſe ſeas; the flat ice, and the mountain ice: the one formed of ſea-water only; the other, of freſh ‡.

The flat, or driving ice, is entirely com-

* Krantz's Hiſtory of Greenland, vol. i. p. 31.

† Buffon, vol. ii. p. 91. ‡ Krantz.

poſed of ſea-water; which upon diſſolution, is found to be ſalt; and is readily diſtinguiſhed from the mountain or freſh-water ice, by its whiteneſs and want of tranſparency. This ice is much more terrible to mariners than that which riſes up in lumps: a ſhip can avoid the one, as it is ſeen at a diſtance; but often gets in among the other, which ſometimes cloſing, cruſhes it to pieces. This, which manifeſtly has a different origin from the freſh-water ice, may perhaps have been produced in the Icy Sea, beneath the Pole; or along the coaſts of Spitzberg, or Nova Zembla.

The mountain-ice, as was ſaid, is different in every reſpect, being formed of freſh water, and appearing hard and tranſparent; it is generally of a pale green colour, though ſome pieces are of a beautiful ſky blue; many large maſſes, alſo, appear grey; and ſome black. If examined more nearly, they are found to be incorporated with earth, ſtones, and bruſh-wood waſhed from the ſhore. On theſe alſo, are ſometimes found, not only earth, but neſts with birds eggs, at ſeveral hundred miles from land. The generality of theſe, though almoſt totally freſh, have, nevertheleſs, a thick cruſt of ſalt-water frozen upon them, probably from the power that ice has ſometimes to produce ice.

Such

Such mountains as are here deſcribed, are moſt uſually ſeen at ſpring-time, and after a violent ſtorm, driving out to ſea, where they at firſt terrify the mariner, and are ſoon after daſhed to pieces by the continual waſhing of the waves; or driven into the warmer regions of the ſouth, there to be melted away. They ſometimes, however, ſtrike back upon their native ſhores, where they ſeem to take root at the feet of mountains; and, as Martius tells us, are ſometimes higher than the mountains themſelves. Thoſe ſeen by him were blue, full of clefts and cavities made by the rain, and crowned with ſnow, which alternately thawing and freezing every year, augmented their ſize. Theſe, compoſed of materials more ſolid than that driving at ſea, preſented a variety of agreeable figures to the eye, that, with a little help from fancy, aſſumed the appearance of trees in bloſſom; the inſide of churches, with arches, pillars, and windows; and the blue coloured rays, darting from within, preſented the reſemblance of a glory.

If we enquire into the origin and formation of theſe, which, as we ſee, are very different from the former, I think we have a very ſatisfactory account of them in Krantz's Hiſtory

Hiſtory of Greenland; and I will take leave to give the paſſage, with a very few alterations. "Theſe mountains of ice," ſays he, "are not ſalt, like the ſea-water, but ſweet; and, therefore, can be formed no where except on the mountains, in rivers, in caverns, and againſt the hills near the ſea-ſhore. The mountains of Greenland are ſo high, that the ſnow which falls upon them, particularly on the north ſide, is, in one night's time, wholly converted into ice: they alſo contain clefts and cavities, where the ſun ſeldom or never injects his rays: beſides theſe, are projections, or landing-places, on the declivities of the ſteepeſt hills, where the rain and ſnow-water lodge, and quickly congeal. When now the accumulated flakes of ſnow ſlide down, or fall with the rain from the eminences above, on theſe prominences; or, when here and there a mountain-ſpring comes rolling down to ſuch a lodging place, where the ice has already ſeated itſelf, they all freeze, and add their tribute to it. This, by degrees, waxes to a body of ice, that can no more be overpowered by the ſun; and which, though it may indeed, at certain ſeaſons, diminiſh by a thaw, yet, upon the whole, through annual acquiſitions, it aſſumes an annual growth. Such a body of ice is often

often prominent far over the rocks. It does not melt on the upper ſurface, but underneath; and alſo cracks into many larger or ſmaller clefts, from whence the thawed water trickles out. By this it becomes, at laſt, ſo weak, that being overloaded with its own ponderous bulk, it breaks looſe, and tumbles down the rocks with a terrible craſh. Where it happens to overhang a precipice on the ſhore, it plunges into the deep with a ſhock like thunder; and with ſuch an agitation of the water, as will overſet a boat at ſome diſtance, as many a poor Greenlander has fatally experienced." Thus are theſe amazing ice-mountains launched forth to ſea, and found floating in the waters round both the Poles. It is theſe that have hindered mariners from diſcovering the extenſive countries that lie round the South Pole; and that probably block up the paſſage to China by the North.

I will conclude this chapter with one effect more, produced by the ſaltneſs of the ſea; which is, the luminous appearance of its waves in the night. All who have been ſpectators of a ſea by night, a little ruffled with winds, ſeldom fail of obſerving its fiery brightneſs. In * ſome places it ſhines as far

* Boyle, vol. i. p. 294.

as

as the eye can reach; at other times, only when the waves boom againſt the ſide of the veſſel, or the oar daſhes into the water. Some ſeas ſhine often; others more ſeldom; ſome, ever when particular winds blow; and others, within a narrow compaſs; a long tract of light being ſeen along the ſurface, whilſt all the reſt is hid in total darkneſs. It is not eaſy to account for theſe extraordinary appearances: ſome have ſuppoſed that a number of luminous inſects produced the effect, and this is in reality ſometimes the caſe; in general, however, they have every reſemblance to that light produced by electricity; and, probably, ariſe from the agitation and daſhing of the ſaline particles of the fluid againſt each other. But the manner in which this is done, for we can produce nothing ſimilar, by any experiments hitherto made, remains for ſome happier accident to diſcover. Our progreſs in the knowledge of nature is ſlow; and it is a mortifying conſideration, that we are hitherto more indebted for ſucceſs to chance than induſtry.

CHAP.

CHAP. XVI.

Of the Tides, Motion, and Currents of the Sea; with their Effects.

IT was ſaid in the former chapter, that the waters of the ſea were kept ſweet by their motion; without which they would ſoon putrefy, and ſpread univerſal infection. If we look for final cauſes, here, indeed, we have a great and an obvious one that preſents itſelf before us. Had the ſea been made without motion, and reſembling a pool of ſtagnant water, the nobler races of animated nature would ſhortly be at an end. Nothing would then be left alive but ſwarms of ill formed creatures, with ſcarce more than vegetable life; and ſubſiſting by putrefaction. Were this extenſive bed of waters entirely quieſcent, millions of the ſmaller reptile kinds would there find a proper retreat to breed and multiply in; they would find there no agitations, no concuſſion in the parts of the fluid to cruſh their feeble frames, or to force them from the places where they were bred: there they would multiply in ſecurity and eaſe, enjoy a ſhort life, and, putrefying, thus again give nouriſhment to numberleſs others, as little worthy of exiſtence as themſelves.

ſelves. But the motion of this great element, effectually deſtroys the number of theſe viler creatures; its currents, and its tides, produce continual agitations, the ſhock of which they are not able to endure; the parts of the fluid rub againſt each other, deſtroy all viſcidities; and the ocean, if I may ſo expreſs it, acquires health by exerciſe.

The moſt obvious motion of the ſea, and the moſt generally acknowledged, is that of its tides. This element is obſerved to flow for certain hours, from ſouth towards north; in which motion or flux, which laſts about ſix hours, the ſea gradually ſwells; ſo that entering the mouths of rivers, it drives back the river waters to their heads. After a continual flux of ſix hours, the ſea ſeems to reſt for a quarter of an hour; and then begins to ebb, or retire back again, from north to ſouth, for ſix hours more; in which time the waters ſinking, the rivers reſume their natural courſe. After a ſeeming pauſe of a quarter of an hour, the ſea again begins to flow as before: and thus it has alternately riſen and fallen, twice a day, ſince the creation.

This amazing appearance did not fail to excite the curioſity, as it did the wonder of the ancients. After ſome wild conjectures of the

the earlieſt philoſophers, it became well known, in the times of Pliny, that the tides were entirely under the influence, in a ſmall degree, of the ſun; but in a much greater of the moon. It was found that there was a flux and reflux of the ſea, in the ſpace of twelve hours fifty minutes, which is exactly the time of a lunar day. It was obſerved, that whenever the moon was in the meridian, or, in other words, as nearly as poſſible over any part of the ſea, that the ſea flowed to that part, and made a tide there; on the contrary, it was found, that when the moon left the meridian, the ſea began to flow back again from whence it came; and there might be ſaid to ebb. Thus far the waters of the ſea ſeemed very regularly to attend the motions of the moon. But it appeared, likewiſe, that when the moon was in the oppoſite meridian, as far off as poſſible on the other ſide of the globe, that there was a tide on this ſide alſo; ſo that the moon produced two tides, one by her greateſt approach to us, and another by her greateſt diſtance from us: in other words, the moon, in once going round the earth, produced two tides, always at the ſame time; one on the part of the globe directly under her; and the other, on the part of the globe directly oppoſite.

Man-

Mankind continued for ſeveral ages content with knowing the general cauſe of theſe wonders, hopeleſs of diſcovering the particular manner of the moon's operation. Kepler was the firſt who conjectured that attraction was the principal cauſe; aſſerting, that the ſphere of the moon's operation extended to the earth, and drew up its waters. The preciſe manner in which this is done, was diſcovered by Newton.

The moon has been found like all the reſt of the planets, to attract, and to be attracted by the earth. This attraction prevails throughout our whole planetary ſyſtem. The more matter there is contained in any body, the more it attracts: and its influence decreaſes in proportion as the diſtance, when ſquared, encreaſes. This being premiſed, let us ſee what muſt enſue upon ſuppoſing the moon in the meridian of any tract of the ſea. The ſurface of the water immediately under the moon, is nearer the moon than any other part of the globe is; and, therefore, muſt be more ſubject to its attraction than the waters any where elſe. The waters will, therefore, be attracted by the moon, and riſe in an heap; whoſe eminence will be the higheſt where the attraction is greateſt. In order to form this eminence, it is obvious

that

that the ſurface, as well as the depths, will be agitated; and that wherever the water runs from one part, ſucceeding waters muſt run to fill up the ſpace it has left. Thus the waters of the ſea, running from all parts, to attend the motions of the moon, produce the flowing of the tide; and it is high tide at that part wherever the moon comes over it, or into its meridian.

But when the moon travels onward, and ceaſes to point over the place where the waters were juſt riſen, the cauſe here of their riſing ceaſing to operate, they will flow back by their natural gravity, into the lower parts from whence they had travelled; and this retiring of the waters will form the ebbing of the ſea.

Thus the firſt part of the demonſtration is obvious; ſince, in general, it requires no great ſagacity to conceive that the waters neareſt the moon are moſt attracted, or raiſed higheſt by the moon. But the other part of the demonſtration, namely, how there come to be high tides at the ſame time, on the oppoſite ſide of the globe, and where the waters are fartheſt from the moon, is not ſo eaſy to conceive. To comprehend this, it muſt be obſerved, that the part of the earth, and its waters, that are fartheſt from the moon, are the parts of all others that are leaſt

leaſt attracted by the moon: it muſt alſo be obſerved, that all the waters, when the moon is on the oppoſite ſide of the earth, muſt be attracted by it in the ſame direction that the earth itſelf attracts them; that is, if I may ſo ſay, quite through the body of the earth, towards the moon itſelf. This, therefore, being conceived, it is plain that thoſe waters which are fartheſt from the moon, will have leſs weight than thoſe of any other part, on the ſame ſide of the globe; becauſe the moon's attraction, which conſpires with the earth's attraction, is there leaſt. Now, therefore, the waters fartheſt from the moon, having leſs weight, and being lighteſt, will be preſſed on all ſides, by thoſe that, having more attraction, are heavier: they will be preſſed, I ſay, on all ſides; and the heavier waters flowing in, will make them ſwell and riſe in an eminence directly oppoſite to that on the other ſide of the globe, cauſed by the more immediate influence of the moon.

In this manner the moon, in one diurnal revolution, produces two tides; one raiſed immediately under the ſphere of its influence, and the other directly oppoſite to it. As the moon travels, this vaſt body of waters rears upward, as if to watch its motions; and purſues the ſame conſtant rotation. However, in this great work of raiſing the tides,

tides, the ſun has no ſmall ſhare; it produces its own tides conſtantly every day, juſt as the moon does, but in a much leſs degree, becauſe the ſun is at an immenſely greater diſtance. Thus there are ſolar tides, and lunar tides. When the forces of theſe two great luminaries concur, which they always do when they are either in the ſame, or in oppoſite parts of the heavens, they jointly produce a much greater tide, than when they are ſo ſituated in the heavens, as each to make peculiar tides of their own. To expreſs the very ſame thing technically; in the conjunctions and oppoſitions of the ſun and moon, the attraction of the ſun conſpires with the attraction of the moon; by which means the high ſpring-tides are formed. But in the quadratures of the ſun and moon, the water raiſed by the one is depreſſed by the other; and hence the lower neap tides have their production. In a word, the tides are greateſt in the ſyzigies, and leaſt in the quadratures.

This theory well underſtood, and the aſtronomical terms previouſly known, it may readily be brought to explain the various appearances of the tides, if the earth were covered with a deep ſea, and the waters uninfluenced by ſhoals, currents, ſtraits, or tempeſts. But in every part of the ſea, near the

ſhores,

ſhores, the geographer muſt come in to correct the calculations of the aſtronomer. For, by reaſon of the ſhallowneſs of ſome places, and the narrowneſs of the ſtraits in others, there ariſes a great diverſity in the effect, not to be accounted for without an exact knowledge of all the circumſtances of the place. In the great depths of the ocean, for inſtance, a very ſlow and imperceptible motion of the whole body of water will ſuffice to raiſe its ſurface ſeveral feet high; but if the ſame encreaſe of water is to be conveyed through a narrow channel, it muſt ruſh thro' it with the moſt impetuous rapidity. Thus in the Engliſh channel, and the German ocean, the tide is found to flow ſtrongeſt in thoſe places that are narroweſt; the ſame quantity of water being, in this caſe, to be driven through a ſmaller paſſage. It is often ſeen, therefore, pouring through a ſtreight with great force; and, by its rapidity, conſiderably raiſed above the ſurface of that part of the ocean into which it runs.

This ſhallowneſs and narrowneſs in many parts of the ſea, give alſo riſe to a peculiarity in the tides of ſome parts of the world. For in many places, and in our own ſeas in particular, the greateſt ſwell of the tide is not while the moon is at its meridian height, and directly over the place, but ſome time after

after it has declined from thence. The ſea, in this caſe, being obſtructed, purſues the moon with what diſpatch it can, but does not arrive with all its waters till long after the moon has ceaſed to operate. Laſtly, from this ſhallowneſs of the ſea, and from its being obſtructed by ſhoals and ſtreights, we may account for the Mediterranean, the Baltic, and the Black Sea, having no ſenſible tides. Theſe, though to us they ſeem very extenſive, are not however large enough to be affected by the influence of the moon; and as to their communication with the ocean, that is through ſuch narrow inlets, that it is impoſſible in a few hours time that they ſhould receive and return water enough to raiſe or depreſs them in any conſiderable degree.

In general, therefore, we may obſerve, that all tides are much higher, and more conſiderable in the torrid zone, than in the reſt of the ocean; the ſea in thoſe parts being generally deeper, and leſs affected by changeable winds, or winding ſhores*. The greateſt tide we know of, is that at the mouth of the river Indus, where the water riſes thirty feet in height. How great, therefore, muſt have been the amazement of Alexander's ſoldiers at ſo ſtrange an appearance! They who always before had been accuſtomed

* Buffon, vol. ii. p. 187.

only to the ſcarcely perceptible riſings of the Mediterranean, or the minute intumeſcence of the Black Sea, when made at once ſpectators of a river riſing and falling thirty feet in a few hours, muſt no doubt have felt the moſt extreme awe, and, as we are told*, a mixture of curioſity and apprehenſion. The tides are alſo remarkably high on the coaſts of Malay, in the ſtreights of Sunda, in the Red Sea, at the mouth of the river St. Lawrence, along the coaſts of China and Japan, at Panama, and in the gulph of Bengal. The tides at Tonquin, however, are the moſt remarkable in the world. In this part there is but one tide, and one ebb, in twenty-four hours; whereas, as we have ſaid before, in other places there are two. Beſides, there, twice in each month there is no tide at all, when the moon is near the equinoctial, the water being for ſome time quite ſtagnant. Theſe, with ſome other odd appearances attending the ſame phænomena, were conſidered by many as inſcrutable; but Sir Iſaac Newton, with peculiar ſagacity, adjudged them to ariſe from the concurrence of two tides, one from the South Sea, and the other from the Indian Ocean. Of each of theſe tides there come ſucceſſively two every day; two at one time greater, and two at another

* Quintus Curtius.

at

that are leſs. The time between the arrival of the two greater, is conſidered by him as high tide; the time between the two leſſer, as ebb. In ſhort, with this clue, that great mathematician ſolved every appearance, and ſo eſtabliſhed his theory as to ſilence every oppoſer.

This fluctuation of the ſea from the tides, produces another, and more conſtant rotation of its waters, from the eaſt to the weſt, in this reſpect following the courſe of the moon. This may be conſidered as one great and general current of the waters of the ſea; and although it be not every where diſtinguiſhable, it is nevertheleſs every where exiſtent, except when oppoſed by ſome particular current or eddy, produced by partial and local cauſes. This tendency of the ſea towards the weſt, is plainly perceivable in all the great ſtreights of the ocean; as, for inſtance, in thoſe of Magellan, where the tide running in from the eaſt, riſes twenty feet high, and continues flowing ſix hours; whereas the ebb continues but two hours, and the current is directed to the weſt. This proves that the flux is not equal to the reflux; and that from both reſults a motion of the ſea weſtward, which is more powerful during the time of the flux than the reflux.

But this motion weſtward has been ſenſibly obſerved by navigators, in their paſſage

back from India to Madagaſcar, and ſo on to Africa. In the great Pacific Ocean alſo, it is very perceivable: but the places where it is moſt obvious are, as was ſaid, in thoſe ſtreights which join one ocean to another. In the ſtreights between the Maldivia iſlands, in the gulph of Mexico, between Cuba and Jucatan. In the ſtreights of the gulph of Paria, the motion is ſo violent that it hath received the appellation of the Dragon's Mouth. Northward, in the ſea of Canada, in Waigat's ſtreights, in the ſtreights of Java, and, in ſhort, in every ſtreight where the ocean on one part pours into the ocean on the other. In this manner, therefore, is the ſea carried with an unceaſing circulation round the globe; and, at the ſame time that its waters are puſhed back and forward with the tide, they have thus a progreſſive current to the weſt, which, though leſs obſervable, is not the leſs real.

Beſides theſe two general motions of the ſea, there are others which are particular to many parts of it, and are called currents. Theſe are found to run in all directions, eaſt, weſt, north, and ſouth; being formed, as was ſaid above, by various cauſes; the prominence of the ſhores, the narrowneſs of the ſtreights, the variations of the wind,

and

and the inequalities at the bottom. Theſe, though no great object to the philoſopher, as their cauſes are generally local and obvious, are nevertheleſs of the moſt material conſequence to the mariner; and, without a knowledge of which, he could never ſucceed. It often has happened, that when a ſhip has unknowingly got into one of theſe, every thing ſeems to go forward with ſucceſs, the mariners ſuppoſe themſelves every hour approaching their wiſh'd-for port, the wind fills their ſails, and the ſhip's prow ſeems to divide the water; but, at laſt, by miſerable experience they find, that inſtead of going forward, they have been all the time receding. The buſineſs of currents, therefore, makes a conſiderable article in navigation; and the direction of their ſtream, and their rapidity, has been carefully ſet down. This ſome do by the obſervation of the ſurface of the current; or by the driving of the froth along the ſhore; or by throwing out what is called the log-line, with a buoy made for that purpoſe, and by the direction and motion of this, they judge of the ſetting, and the rapidity of the current.

Theſe currents are generally found to be moſt violent under the equator, where indeed all the motions of the ocean are moſt perceivable.

ceivable. Along the coaſts of Guinea, if a ſhip happens to overſhoot the mouth of any river it is bound to, the current prevents its return; ſo that it is obliged to ſteer out to ſea, and take a very large compaſs, in order to correct the former miſtake. Theſe ſet in a contrary direction to the general motion of the ſea weſtward; and that ſo ſtrongly, that a paſſage which with the current is gone in two days, is with difficulty performed in ſix weeks againſt it. However, they do not extend above twenty leagues from the coaſt; and ſhips going to the Eaſt-Indies, take care not to come within the ſphere of their action. At Sumatra, the currents, which are extremely rapid, run from ſouth to north: there are alſo ſtrong currents between Madagaſcar and the Cape of Good Hope. On the weſtern coaſts of America, the current always runs from the ſouth to the north, where a ſouth wind, continually blowing, moſt probably occaſions this phænomena. But the currents that are moſt remarkable, are thoſe continually flowing into the Mediterranean ſea, both from the ocean by the ſtreights of Gibraltar, and at its other extremity, from the Euxine ſea by the Archipelago. This is one of the moſt extraordinary appearances in nature, this large ſea receiving not only the numerous rivers that fall

into

into it, ſuch as the Nile, the Rhone, and the Po, but alſo a very great influx from the Euxine ſea on one part, and the ocean on the other. At the ſame time, it is ſeen to return none of thoſe waters it is thus known to receive: outlets running from it there are none; no rivers but ſuch as bring it freſh ſupplies; no ſtreights but what are conſtantly pouring their waters into it: it has therefore been the wonder of mankind in every age, how, and by what means this vaſt concourſe of waters are diſpoſed of; or how this ſea, which is always receiving, and never returning, is no way fuller than before. In order to account for this, ſome have ſaid, that the water was re-conveyed by ſubterraneous paſſages into the Red Sea*. There is a ſtory told of an Arabian califf, who caught a dolphin in this ſea, admiring the beauty of which, he let it go again, having previouſly marked it by a ring of iron. Some time after a dolphin was caught in the Red Sea, and quickly known by the ring to be the ſame that had been taken in the Mediterranean before. Such, however, as have not been willing to found their opinions upon a ſtory, have attempted to account for the diſpoſal of the waters of the Mediterranean by evaporation. For this purpoſe they have

* Kircher Mund. Subt. vol. i.

entered

entered into long calculations upon the extent of its ſurface, and the quantity of water that would be raiſed from ſuch a ſurface in a year. They then compute how much water runs in by its rivers and ſtreights in that time; and find, that the quantity exhauſted by evaporation, greatly exceeds the quantity ſupplied by rivers and ſeas. And this ſolution, no doubt would be ſatisfactory, did not the ocean, and the Euxine, evaporate as well as the Mediterranean: and as theſe are ſubject to the ſame drain, it muſt follow, that all the ſeas will in this reſpect be upon a par; and, therefore, there muſt be ſome other cauſe for this unperceived drain, and continual ſupply. This ſeems to be ſatisfactorily enough accounted for by Doctor Smith, who ſuppoſes an under current running through the ſtreights of Gibraltar to carry out as much water into the ocean, as the upper current continually carries in from it. To confirm this, he obſerves, that nearer home, between the north and ſouth foreland, the tide is known to run one way at top, and the ebb another way at bottom. This double current he alſo confirms by an experiment communicated to him by an able ſeaman, who being with one of the king's frigates in the Baltic, found he went with his boat into the mid-ſtream, and was carried violently by the current; upon which

a baſket

a baſket was ſunk, with a large cannon-ball, to a certain depth of water, which gave a check to the boat's motion; as the baſket ſunk ſtill lower, the boat was driven, by the force of the water below, againſt the upper current; and the lower the baſket was let down, the ſtronger the under current was found, and the quicker was the boat's motion againſt the upper ſtream, which ſeemed not to be above four fathom deep. From hence we may readily infer, that the ſame cauſe may operate at the ſtreights of Gibraltar; and that while the Mediterranean ſeems repleniſhing at top it may be emptying at bottom.

The number of the currents at ſea are impoſſible to be recounted, nor indeed are they always known; new ones are daily produced by a variety of cauſes, and as quickly diſappear. When a regular current is oppoſed by another in a narrow ſtreight, or where the bottom of the ſea is very uneven, a whirlpool is often formed. Theſe were formerly conſidered as the moſt formidable obſtructions to navigation, and the ancient poets and hiſtorians ſpeak of them with terror; they are deſcribed as ſwallowing up ſhips, and daſhing them againſt the rocks at the bottom; apprehenſion did not fail to add imaginary terrors to the deſcription, and placed at the center of the whirlpool a dreadful den, fraught with monſters,

whoſe

whoſe howlings ſerved to add new horrors to the daſhing of the deep. Mankind at preſent, however, view theſe eddies of the ſea with very little apprehenſion; and ſome have wondered how the ancients could have ſo much overcharged their deſcriptions. But all this is very naturally accounted for. In thoſe times when navigation was as yet but beginning, and the ſlighteſt concuſſion of the waves generally ſent the poor adventurer to the bottom, it is not to be wondered at that he was terrified at the violent agitations in one of theſe. When his little ſhip, but ill fitted for oppoſing the fury of the ſea, was got within the vortex, there was then no poſſibility of ever returning. To add to the fatality, they were always near the ſhore; and along the ſhore was the only place where this ill provided mariner durſt venture to ſail. Theſe were, therefore, dreadful impediments to his navigation; for if he attempted to paſs between them and the ſhore, he was ſometimes ſucked in by the eddy; and if he attempted to avoid them out at ſea, he was often ſunk by the ſtorm. But in our time, and in our preſent improved ſtate of navigation, Charybdis, and the Euripus, with all the other irregular currents of the Mediterranean, are no longer formidable. Mr. Addiſon not attending

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to this train of thinking, upon paſſing through the ſtreights of Sicily, was ſurpriſed at the little there was of terror in the preſent appearance of Scylla and Charybdis; and ſeems to be of opinion, that their agitations are much diminiſhed ſince the times of antiquity. In fact, from the reaſons above, all the wonders of the Mediterranean ſea are deſcribed in much higher colours than they merit, to us who are acquainted with the more magnificent terrors of the ocean. The Mediterranean is one of the ſmootheſt and moſt gentle ſeas in the world; its tides are ſcarce perceivable, except in the gulph of Venice, and ſhipwrecks are leſs known there than in any other part of the world.

It is in the ocean, therefore, that theſe whirlpools are particularly dangerous, where the tides are violent, and the tempeſts fierce. To mention only one, that called the Maelſtroom, upon the coaſts of Norway, which is conſidered as the moſt dreadful and voracious in the world. The name it has received from the natives, ſignifies the navel of the ſea, ſince they ſuppoſe that a great ſhare of the water of the ſea is ſucked up and diſcharged by its vortex. A minute deſcription of the internal parts is not to be expected, ſince none who were there ever returned to bring back information. The body

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of the waters that form this whirlpool, are extended in a circle above thirteen miles in circumference *. In the midſt of this ſtands a rock, againſt which the tide in its ebb is daſhed with inconceivable fury. At this time it inſtantly ſwallows up all things that come within the ſphere of its violence, trees, timber, and ſhipping. No ſkill in the mariner, nor ſtrength of rowing, can work an eſcape: the ſailor at the helm finds the ſhip at firſt go into a current oppoſite to his intentions; his veſſel's motion, tho' ſlow in the beginning, becomes every moment more rapid; it goes round in circles ſtill narrower and narrower, till it laſt it is daſhed againſt the rocks, and inſtantly diſappears: nor is it ſeen again for ſix hours: till the tide flowing, it is vomited forth with the ſame violence with which it was drawn in. The noiſe of this dreadful vortex ſtill farther contributes to encreaſe its terror, which with the daſhing of the waters, and the dreadful valley, if it may be ſo called, cauſed by their circulation, makes one of the moſt tremendous objects in nature.

* Kircher Mund. Subt. vol. i. p. 156.

CHAP.

CHAP. XVII.

Of the Changes produced by the Sea upon the Earth.

FROM what has been ſaid, as well of the earth as of the ſea, they both appear to be in continual fluctuation. The earth, the common promptuary that ſupplies ſubſiſtence to men, animals, and vegetables, is continually furniſhing its ſtores to their ſupport. But the matter which is thus derived from it, is ſoon reſtored and laid down again to be prepared for freſh mutations. The tranſmigration of ſouls is no doubt falſe and whimſical; but nothing can be more certain than the tranſmigration of bodies: the ſpoils of the meaneſt reptile may go to the formation of a prince; and, on the contrary, as the poet has it, the body of Cæſar may be employed in ſtopping a beer barrel. From this, and other cauſes, therefore, the earth is in continual change. Its internal fires, the deviation of its rivers, and the falling of its mountains, are daily altering its ſurface; and geography can ſcarce recollect the lakes and the vallies that hiſtory once deſcribed.

But theſe changes are nothing to the inſta-

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bility of the ocean. It would ſeem that inquietude was as natural to it as its fluidity. It is firſt ſeen with a conſtant and equable motion going towards the weſt; the tides then interrupt this progreſſion, and for a time drive the waters in a contrary direction; beſide theſe agitations, the currents act their part in a ſmaller ſphere, being generally greateſt where the other motions of the ſea are leaſt; namely, neareſt the ſhore: the winds alſo contribute their ſhare in this univerſal fluctuation; ſo that ſcarce any part of the ſea is wholly ſeen to ſtagnate.

Nil enim quieſcit, undis impellitur unda,
Et ſpiritus et calor toto ſe corpore miſcent.

As this great element is thus changed, and continually labouring internally, it may be readily ſuppoſed that it produces correſpondent changes upon its ſhores, and thoſe parts of the earth ſubject to its influence. In fact, it is every day making conſiderable alterations, either by overflowing its ſhores in one place, or deſerting them in others; by covering over whole tracts of country, that were cultivated and peopled, at one time; or by leaving its bed to be appropriated to the purpoſes of vegetation, and to ſupply a new theatre for human induſtry at another.

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In this ſtruggle between the earth and the ſea for dominion, the greateſt number of our ſhores ſeem to defy the whole rage of the waves, both by their height, and the rocky materials of which they are compoſed. The coaſts of Italy, for inſtance *, are bordered with rocks of marble of different kinds, the quarries of which may eaſily be diſtinguiſhed at a diſtance from ſea, and appear like perpendicular columns, of the moſt beautiful kinds of marble, ranged along the ſhore. In general, the coaſts of France, from Breſt to Bourdeaux, are compoſed of rocks; as are alſo thoſe of Spain and England, which defend the land, and only are interrupted here and there to give an egreſs to rivers, and to grant the conveniences of bays and harbours to our ſhipping. It may be in general remarked, that wherever the ſea is moſt violent and furious, there the boldeſt ſhores, and of the moſt compact materials, are found to oppoſe it. There are many ſhores ſeveral hundred feet perpendicular, againſt which the ſea, when ſwollen with tides or ſtorms, riſes and beats with inconceivable fury. In † the Orkneys, where the ſhores are thus formed, it ſometimes, when agitated by a ſtorm, riſes two hundred feet perpendicular, and daſhes

* Buffon, vol. ii. p. 199. † Idem, vol. ii. p. 191.

up

up its ſpray, together with ſand, and other ſubſtances that compoſe its bottom, upon land, like ſhowers of rain.

From hence, therefore, we may conceive how the violence of the ſea, and the boldneſs of the ſhore, may be ſaid to have made each other. Where the ſea meets no obſtacles, it ſpreads its waters with a gentle intumeſcence, till all its power is deſtroyed, by its wanting depth to aid its motion. But when its progreſs is checked in the midſt, by the prominence of rocks, or the abrupt elevation of the land, it daſhes with all the force of its depth againſt the obſtacle, and forms, by its repeated violence, the abruptneſs of the ſhore which confines its impetuoſity. Where the ſea is extremely deep, or very much vexed by tempeſts, it is no ſmall obſtacle that can confine its rage; and for this reaſon we ſee the boldeſt ſhores projected againſt the deepeſt waters; all leſs impediments having long before been ſurmounted and waſhed away. Perhaps of all the ſhores in the world, there is not one ſo high as that to the weſt of St. Kilda, which, upon a late admeaſurement *, was found to be ſix hundred fathom perpendicular above the ſurface of the ſea. Here alſo, the ſea is deep, turbulent,

* Deſcription of St. Kilda.

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and ſtormy; ſo that it requires great force in the ſhore to oppoſe its violence. In many parts of the world, and particularly upon the coaſts of the Eaſt Indies, the ſhores, though not high above water, are generally very deep, and conſequently the waves roll againſt land with great weight and irregularity. This riſing of the waves againſt the ſhore, is called by mariners, the ſurf of the ſea; and in ſhipwrecks is generally fatal to ſuch as attempt to ſwim on ſhore. In this caſe, no dexterity in the ſwimmer, no float he can uſe, neither ſwimming girdle nor cork jacket will ſave him; the weight of the ſuperincumbent wave breaks upon him at once, and cruſhes him with certain ruin. Some few of the natives, however, have the art of ſwimming and of navigating their little boats near thoſe ſhores, where an European is ſure of inſtant deſtruction.

In places where the force of the ſea is leſs violent, or its tides leſs rapid, the ſhores are generally ſeen to deſcend with a more gradual declivity. Over theſe, the waters of the tide ſteal by almoſt imperceptible degrees, covering them for a large extent, and leaving them bare on its receſs. Upon theſe ſhores, as was ſaid, the ſea ſeldom beats with any great violence, as a large wave has not depth ſufficient to float it onwards, ſo that

here only are to be ſeen gentle ſurges making calmly towards land, and leſſening as they approach. As the ſea, in the former deſcription, is generally ſeen to preſent proſpects of tumult, and uproar, here it more uſually exhibits a ſcene of repoſe and tranquil beauty. Its waters, which when ſurveyed from the precipice, afforded a muddy greeniſh hue, ariſing from their depth and poſition to the eye*, when regarded from a ſhelving ſhore, wear the colour of the ſky, and ſeem riſing to meet it. The deafening noiſe of the deep ſea, is here converted into gentle murmurs; inſtead of the water's daſhing againſt the face of the rock, it advances and recedes, ſtill going forward, but with juſt force enough to puſh its weeds and ſhells, by inſenſible approaches, to the ſhore.

There are ſtill other ſhores, beſide thoſe already deſcribed, which either have been raiſed by art to oppoſe the ſea's approaches, or from the ſea's gaining ground, are threatened with imminent deſtruction. The ſea's being thus ſeen to give and take away lands at pleaſure, is, without queſtion, one of the moſt extraordinary conſiderations in all natural hiſtory. In ſome places it is ſeen to obtain the ſuperiority by ſlow and certain approaches; or to burſt in at once, and

* Newton's Optics, p. 163—167.

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overwhelm all things in undiſtinguiſhed deſtruction; in other places it departs from its ſhores, and where its waters have been known to rage, it leaves fields covered with the moſt beautiful verdure.

The formation of new lands by the ſea's continually bringing its ſediment to one place, and by the accumulation of its ſands in another, is eaſily conceived. We have had many inſtances of this in England. The iſland of Oxney, which is adjacent to Romney-marſh, was produced in this manner. This had for a long time been a low level, continually in danger of being overflown by the river Rother; but the ſea, by its depoſitions, has gradually raiſed the bottom of the river, while it has hollowed the mouth; ſo that the one is ſufficiently ſecured from inundations, and the other is deep enough to admit ſhips of conſiderable burthen. The like alſo may be ſeen at that bank called the Dogger-ſands, where two tides meet, and which thus receive new increaſe every day, ſo that in time the place ſeems to promiſe fair for being habitable earth. On many parts of the coaſts of France, England, Holland, Germany, and Pruſſia, the ſea has been ſenſibly known to retire*. Hubert Thomas aſſerts, in his Deſcription of the Country of

* Buffon, vol. vi. p. 424.

Liege, that the ſea formerly encompaſſed the city of Tongres, which, however, is at preſent thirty-five leagues diſtant from it: this aſſertion he ſupports by many ſtrong reaſons; and among others, by the iron rings fixed in the walls of the town, for faſtening the ſhips that came into the port. In Italy there is a conſiderable piece of ground gained at the mouth of the river Arno; and Ravenna, that once ſtood by the ſea-ſide is now conſiderably removed from the ſame. But we need ſcarce mention theſe, when we find that the whole kingdom of Holland ſeems to be a conqueſt upon the ſea, and in a manner reſcued from its boſom. The ſurface of the earth, in this country, is below the level of the bed of the ſea; and I remember, upon approaching the coaſt, to have looked down upon it from the ſea, as into a valley; however, it is every day riſing higher by the depoſitions made upon it, both by the ſea, the Rhine, and the Meuſe; and thoſe parts which formerly admitted large men of war, are now known to be too ſhallow to receive ſhips of very moderate burthen*. The province of Jucatan, a peninſula in the gulph of Mexico, was formerly a part of the ſea: this tract, which ſtretches out into the ocean an hundred

* Buffon, vol. vi. p. 424.

leagues,

leagues, and which is above thirty broad, is every where, at a moderate depth below the ſurface, compoſed of ſhells, which evince that its land once formed the bed of the ſea. In France, the town of Aigues Mortes was a port in the times of St. Louis, which is now removed more than four miles from the ſea. Pſalmodi, in the ſame kingdom, was an iſland in the year 815, but is now more than ſix miles from the ſhore. All along the coaſts of Norfolk, I am very well aſſured, that in the memory of man, the ſea has gained fifty yards in ſome places, and has loſt as much in others.

Thus numerous, therefore, are the inſtances of new lands having been produced from the ſea, which, as we ſee, is brought about two different ways: firſt, by the waters raiſing banks of ſand and mud where their ſediment is depoſited; and ſecondly, by their relinquiſhing the ſhore entirely, and leaving it unoccupied to the induſtry of man.

But as the ſea has been thus known to recede from ſome lands, ſo has it, by fatal experience, been found to encroach upon others: and, probably, theſe depredations on one part of the ſhore, may account for their dereliction from another; for the current which reſted upon ſome certain bank, having got an egreſs in ſome other place, it no longer

longer preſſes upon its former bed, but pours all its ſtream into the new entrance, ſo that every inundation of the ſea may be attended with ſome correſpondent dereliction of another ſhore.

However this be, we have numerous hiſtories of the ſea's inundations, and its burying whole provinces in its boſom. Many countries that have been thus deſtroyed, ſtill bear melancholy witneſs to the truth of hiſtory; and ſhew the tops of their houſes, and the ſpires of their ſteeples, ſtill ſtanding at the bottom of the water. One of the moſt conſiderable inundations we have in hiſtory, is that which happened in the reign of Henry I. which overflowed the eſtates of the Earl Godwin, and forms now that bank called the Goodwin ſands. In the year 1546, a ſimilar irruption of the ſea deſtroyed an hundred thouſand perſons in the territory of Dort; and yet a greater number round Dullart. In Friezland, and Zealand, there were more than three hundred villages overwhelmed; and their remains continue ſtill viſible at the bottom of the water in a clear day. The Baltic ſea has, by ſlow degrees, covered a large part of Pomerania; and, among others, deſtroyed and overwhelmed the famous port of Vineta. In the ſame manner, the Norwegian ſea has formed ſeveral little iſlands

from

from the main land, and ſtill daily advances upon the continent. The German ſea has advanced upon the ſhores of Holland, near Catt, ſo that the ruins of an ancient citadel of the Romans, which was formerly built upon this coaſt, are now actually under water. To theſe accidents ſeveral more might be added; our own hiſtorians, and thoſe of other countries, abound with them; almoſt every flat ſhore of any extent, being able to ſhew ſomething that it has loſt, or ſomething that it has gained from the ſea.

There are ſome ſhores on which the ſea has made temporary depredations; where it has overflowed, and after remaining perhaps ſome ages, it has again retired of its own accord, or been driven back by the induſtry of man *. There are many lands in Norway, Scotland, and the Maldivia iſlands, that are at one time covered with water, and at another free. The country round the Iſle of Ely, in the times of Bede, about a thouſand years ago, was one of the moſt delightful ſpots in the whole kingdom. It was not only richly cultivated, and produced all the neceſſaries of life, but grapes alſo that afforded the moſt excellent wine. The accounts of that time are copious in the deſcription of its verdure and fertility; its rich paſtures,

* Buffon, vol. ii. p. 425.

covered

covered with flowers and herbage; its beautiful ſhades, and wholſome air. But the ſea breaking in, upon the land, overwhelmed the whole country, took poſſeſſion of the ſoil, and totally deſtroyed one of the moſt beautiful vallies in the world. Its air, from being dry and healthful, from that time became moſt unwholſome, and clogged with vapours; and the ſmall part of the country that, by being higher than the reſt, eſcaped the deluge, was ſoon rendered uninhabitable, from its noxious vapours. Thus this country continued under water for ſome centuries; till, at laſt, the ſea, by the ſame caprice which had prompted its invaſions, began to abandon the earth in like manner. It has continued for ſome ages to relinquiſh its former conqueſts; and although the inhabitants can neither boaſt the longevity, nor the luxuries of their former pre-occupants, yet they find ample means of ſubſiſtence; and if they happen to ſurvive the firſt years of their reſidence there, they are often known to arrive at a good old age.

But although hiſtory be ſilent as to many other inundations of the like kind, where the ſea has overflowed the country, and afterwards retired, yet we have numberleſs teſtimonies of another nature, that prove it beyond the poſſibility of doubt: I mean thoſe numerous trees that are found buried at

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conſiderable depths in places where either rivers, or the ſea, has accidentally overflown *. At the mouth of the river Neſs, near Bruges, in Flanders, at the depth of fifty feet, are found great quantities of trees lying as cloſe to each other as they do in a wood: the trunks, the branches, and the leaves, are in ſuch perfect preſervation, that the particular kind of each tree may inſtantly be known. About five hundred years ago, this very ground was known to have been covered with the ſea; nor is there any hiſtory or tradition of its having been dry ground, which we can have no doubt muſt have been the caſe. Thus we ſee a country flouriſhing in verdure, producing large foreſts, and trees of various kinds, overwhelmed by the ſea. We ſee this element depoſiting its ſediment to an heighth of fifty feet; and its waters muſt, therefore, have riſen much higher. We ſee the ſame, after it has thus overwhelmed, and ſunk the land ſo deep beneath its ſlime, capriciouſly retiring from the ſame coaſts, and leaving that habitable once more, which it had formerly deſtroyed. All this is wonderful; and perhaps, inſtead of attempting to enquire after the cauſe, which has hitherto been inſcrutable, it will beſt become us to reſt ſatisfied with admiration.

* Buffon, vol. ii. p. 403.

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At the city of Modena in Italy, and about four miles round it, wherever it is dug, when the workmen arrive at the depth of ſixty-three feet, they come to a bed of chalk, which they bore with an augre five feet deep: they then withdraw from the pit, before the augre is removed, and upon its extraction, the water burſts up through the aperture with great violence, and quickly fills this new made well, which continues full, and is affected neither by rains nor droughts. But that which is moſt remarkable in this operation, is the layers of earth as we deſcend. At the depth of fourteen feet, are found the ruins of an ancient city, paved ſtreets, houſes, floors, and different pieces of Moſaic. Under this is found a ſolid earth, that would induce one to think had never been removed; however, under it is found a ſoft oozy earth, made up of vegetables; and at twenty-ſix feet depth, large trees entire, ſuch as walnut-trees, with the walnuts ſtill ſticking on the ſtem, and their leaves and branches in exact preſervation. At twenty-eight feet deep, a ſoft chalk is found, mixed with a vaſt quantity of ſhells; and this bed is eleven feet thick. Under this, vegetables are found again, with leaves, and branches of trees as before; and thus alternately chalk and vegetable earth to the depth of ſixty-three feet. Theſe are

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the layers wherever the workmen attempt to bore; while in many of them, they alſo find pieces of charcoal, bones, and bits of iron. From this deſcription, therefore, it appears, that this country has been alternately overflowed and deſerted by the ſea, one age after another: nor were theſe overflowings and retirings of trifling depth, or of ſhort continuance. When the ſea burſt in, it muſt have been a long time in overwhelming the branches of the fallen foreſt with its ſediment; and ſtill longer in forming a regular bed of ſhells eleven feet over them. It muſt have, therefore, taken an age, at leaſt, to make any one of theſe layers; and we may conclude, that it muſt have been many ages employed in the production of them all. The land alſo, upon being deſerted, muſt have had time to grow compact, to gather freſh fertility, and to be drained of its waters before it could be diſpoſed to vegetation; or before its trees could have ſhot forth again to maturity.

We have inſtances nearer home of the ſame kind, given us in the Philoſophical Tranſactions; one of them by Mr. Derham. An inundation of the ſea, at Dagenham, in Eſſex, laying bare a part of the adjacent paſture, for above two hundred feet wide, and, in ſome places, twenty deep, it diſcovered a number

number of trees that had lain there for many ages before; theſe trees, by lying long under ground, were become black and hard, and their fibres ſo tough, that one might as eaſily break a wire, as any of them: they lay ſo thick in the place where they were found, that in many parts he could ſtep from one to another: he conceived alſo, that not only all the adjacent marſhes, for ſeveral hundred acres, were covered underneath with ſuch timber, but alſo the marſhes along the mouth of the Thames, for ſeveral miles. The meeting with theſe trees at ſuch depths, he aſcribes to the ſediment of the river, and the tides, which conſtantly waſhing over them, have always left ſome part of their ſubſtance behind, ſo as, by repeated alluvions, to work a bed of vegetable earth over them, to the height at which he found it.

The levels of Hatfield-Chace, in Yorkſhire, a tract of above eighteen thouſand acres, which was yearly overflown, was reduced to arable and paſture-land, by one Sir Cornelius Vermuſden, a Dutchman. At the bottom of this wide extent, are found millions of the roots and bodies of trees, of ſuch as this iſland either formerly did, or does at preſent produce. The roots of all ſtand in their proper poſtures; and by them, as thick as ever they could grow,

grow, the reſpective trunks of each, ſome above thirty yards long. The oaks, ſome of which have been ſold for fifteen pounds a piece, are as black as ebony, very laſting, and cloſe grained. The aſh-trees are as ſoft as earth, and are commonly cut in pieces by the workmen's ſpades, and as ſoon as flung up in the open air, turn to duſt. But all the reſt, even the willows themſelves, which are ſofter than the aſh, preſerve their ſubſtance and texture to this very day. Some of the firs appear to have vegetated, even after they were fallen, and to have, from their branches, ſtruck up large trees, as great as the parent trunk. It is obſerveable, that many of theſe trees have been burnt, ſome quite through, ſome on one ſide, ſome have been found chopped and ſquared, others riven with great wooden wedges, all ſufficiently manifeſting, that the country which was deluged, had formerly been inhabited. Near a great root of one tree, were found eight coins of the Roman emperors; and, in ſome places, the marks of the ridge and furrow were plainly perceivable, which teſtified that the ground had formerly been patient of cultivation.

The learned naturaliſt who has given this deſcription *, has pretty plainly evinced, that

* Phil. Tranſ. vol. iv. part ii. p. 214.

this

this foreſt, in particular, muſt have been thus levelled by the Romans; and that the falling of the trees, muſt have contributed to the accumulation of the waters. "The Romans," ſays he, "when the Britons fled, always purſued them into the fortreſſes of low woods, and miry foreſts: in theſe, the wild natives found ſhelter; and when opportunity offered, iſſued out, and fell upon their invaders without mercy. In this manner, the Romans were at length ſo harraſſed, that orders were iſſued out for cutting down all the woods and foreſts in Britain. In order to effect this and deſtroy the enemy the eaſier, they ſet fire to the woods, compoſed of pines, and other inflammable timber, which ſpreading, the conflagration deſtroyed not only the foreſt, but infinite numbers of the wretched inhabitants who had taken ſhelter therein. When the pine-trees had thus done what miſchief they could, the Romans then brought their army nearer, and, with whole legions of the captive Britons, cut down moſt of the trees that were yet left ſtanding; leaving only here and there ſome great trees untouched, as monuments of their fury. Theſe, unneedful of their labour, being deſtitute of the ſupport of their underwood, and of their neighbouring trees, were eaſily overthrown by the winds, and, without interruption,

terruption, remained on the places where they happened to fall. The foreſt, thus fallen, muſt neceſſarily have ſtopped up the currents, both from land and ſea; and turned into great lakes, what were before but temporary ſtreams. The working of the waters here, the conſumption and decay of rotten boughs and branches, and the vaſt encreaſe of water-moſs which flouriſhes upon marſhy grounds, ſoon formed a covering over the trunks of the fallen trees, and raiſed the earth ſeveral feet above its former level. The earth thus every day ſwelling, by a continual encreaſe from the ſediment of the waters, and by the lightneſs of the vegetable ſubſtances of which it was compoſed, ſoon overtopt the waters by which this intumeſcence was at firſt affected; ſo that it entirely got rid of its inundations, or only demanded a ſlight aſſiſtance from man for that purpoſe." And this may be the origin of all bogs whatſoever, which are formed by the putrefaction of vegetable ſubſtances, mixed with the mud and ſlime depoſited by waters, and at length acquiring a ſufficient conſiſtency.

From this we ſee what powerful effects the ſea is capable of producing upon its ſhores, either by overflowing ſome, or deſerting others; by altering the direction

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of theſe, and rendering thoſe craggy and precipitate, which before were ſhelving. But the influence it has upon theſe, is nothing to that which it has upon that great body of earth which forms its bottom. It is at the bottom of the ſea that the greateſt wonders are performed, and the moſt rapid changes are produced; it is there that the motion of the tides and the currents have their whole force, and agitate the ſubſtances of which their bed is compoſed. But all theſe are almoſt wholly hid from human curioſity; the miracles of the deep are performed in ſecret; and we have but little information from its abyſſes, except what we receive by inſpection at very ſhallow depths, or by the plummet, or from divers, who are known to deſcend from twenty to thirty fathom *.

The eye can reach but a very ſhort way into the depths of the ſea; and that only when its ſurface is glaſſy and ſerene. In many ſeas it perceives nothing but a bright ſandy plain at bottom, extending for ſeveral hundred miles, without an intervening object. But in others, particularly in the Red Sea, it is very different; the whole bottom of this extenſive bed of waters is, literally ſpeaking, a foreſt of ſubmarine

* Phil. Tranſ. vol. iv. part ii. p. 192.

plants,

plants, and corals formed by inſects for their habitation, ſometimes branching out to a great extent. Here are ſeen the madrepores, the ſponges, moſſes, ſea muſhrooms, and other marine productions, covering every part of the bottom; ſo that ſome have even ſuppoſed the ſea to have taken its name from the colour of its plants below. However, theſe plants are by no means peculiar to this ſea, as they are found in great quantities in the Perſian gulph, along the coaſts of Africa, and thoſe of Provence and Catalonia.

The bottom of many parts of the ſea near America, preſents a very different, though a very beautiful appearance. This is covered with vegetables, which make it look as green as a meadow, and beneath are ſeen thouſands of turtles, and other ſea animals, feeding thereon.

In order to extend our knowledge of the ſea to greater depths, recourſe has been had to the plummet; which is generally made of a lump of lead of about forty pounds weight, faſtened to a cord *. This, however, only anſwers in moderate depths; for when a deep ſea is to be ſounded, the matter of which the cord is compoſed, being lighter than the water, floats upon it,

* Buffon, vol. ii. p. 5.

and when let down to a conſiderable depth, its length ſo encreaſes its ſurface, that it is often ſufficient to prevent the lead from ſinking; ſo that this may be the reaſon that ſome parts of the ſea are ſaid to have no bottom.

In general, we learn from the plummet, that the bottom of the ſea is tolerably even where it has been examined; and that the farther from the ſhore, the ſea is in general the deeper. Notwithſtanding, now and then, in the midſt of a great and unfathomable ocean, we often find an iſland raiſing its head, and ſingly braving its fury. Such iſlands may be conſidered as the mountains of the deep; and, could we for a moment imagine the waters of the ocean removed, or dried away, we ſhould probably find the inequalities of its bed reſembling thoſe that are found at land. Here extenſive plains; there valleys; and, in many places mountains of amazing height. M. Buache has actually given us a map of that part of its bottom, which lies between Africa and America, taken from the ſeveral ſoundings of mariners: in it we find the ſame uneven ſurface that we do upon land, the ſame eminences, and the ſame depreſſions. In ſuch an imaginary proſpect, however, there would be this difference, that as the tops of land mountains appear the moſt barren

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and rocky, the tops of ſea-mountains would be found the moſt verdant and fruitful.

The plummet, which thus gives us ſome idea of the inequalities of the bottom, leaves us totally in the dark as to every other particular; recourſe, therefore, has been had to divers: theſe, either being bred up in this dangerous way of life, and accuſtomed to remain ſome time under water without breathing, or aſſiſted by means of a diving-bell, have been able to return ſome confuſed and uncertain accounts of the places below. In the great diving-bell improved by Doctor Halley, which was large enough to contain five men, and was ſupplied with freſh air by buckets, that alternately roſe and fell, they deſcended fifty fathom. In this huge machine, which was let down from the maſt of the ſhip, the doctor himſelf went down to the bottom, where when the ſea was clear, and eſpecially when the ſun ſhone, he could ſee perfectly well to write or read, and much more to take up any thing that was underneath: at other times, when the water was troubled and thick, it was as dark as night below, ſo that he was obliged to keep a candle lighted at the bottom. But there is one thing very remarkable, which is, that the water which from above was uſually ſeen of a green colour, when looked at from below, appeared

to him of a very different one, caſting a redneſs upon one of his hands, like that of damaſk roſes *.--- A proof of the ſea's taking its colour not from any thing floating in it, but from the different reflexions of the rays of light. Upon the whole, the accounts we have received from the bottom, by this contrivance, are but few. We learn from it, and from divers in general, that while the ſurface of the ſea may be deformed by tempeſts, it is uſually calm and temperate beleow †; that ſome divers who have gone down when the weather was calm, and came up when it was tempeſtuous, were ſurprized at their not perceiving the change at the bottom. This, however, muſt not be ſuppoſed to obtain with regard to the tides, and the currents, as they are ſeen conſtantly ſhifting their bottom; taking their bed with great violence from one place, and depoſiting it upon another. We are informed, alſo, by divers, that the ſea grows colder in proportion as they deſcend to the bottom; that as far as the ſun's rays pierce, it is influenced by their warmth; but lower, the cold becomes almoſt intolerable. A perſon of quality, who had been himſelf a diver, as Mr. Boyle informs us, declared, that though he ſeldom deſcended above three or four fathoms, yet he found it

* Newton's Optic, p. 56. † Boyle, vol. iii. p. 242.

ſo

ſo much colder than near the top, that he could not well endure it; and that being let down in a great diving-bell, although the water could not immediately touch him, he found the air extremely cold upon his firſt arrival at the bottom.

From divers alſo we learn, that the ſea in many places is filled with rocks at bottom; and that among their clifts, and upon their ſides, various ſubſtances ſprout forward, which are either really vegetables, or the neſts of inſects, encreaſed to ſome magnitude. Some of theſe aſſume the ſhape of beautiful flowers; and, tho' ſoft, when taken up, ſoon harden, and are kept in the cabinets of the curious.

But, of all thoſe divers who have brought us information from the bottom of the deep, the famous Nicola Peſce, whoſe performances are told us by Kircher, is the moſt celebrated. I will not ſo much as pretend to vouch for the veracity of Kircher's account, which he aſſures us he had from the archives of the kings of Sicily; but it may ſerve to enliven an heavy chapter. "In the times of Frederic, king of Sicily, there lived a celebrated diver, whoſe name was Nicolas, and who, from his amazing ſkill in ſwimming, and his perſeverance under water, was ſurnamed the fiſh.

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This man had, from his infancy, been uſed to the ſea; and earned his ſcanty ſubſiſtence by diving for corals, and oyſters; which he ſold to the villages on ſhore. His long acquaintance with the ſea, at laſt, brought it to be almoſt his natural element. He frequently was known to ſpend five days in the midſt of the waves, without any other proviſions than the fiſh which he caught there, and ate raw. He often ſwam over from Sicily into Calabria, a tempeſtuous and dangerous paſſage, carrying letters from the king. He was frequently known to ſwim among the gulphs of the Lipari iſlands, no way apprehenſive of danger.

"Some mariners out at ſea one day obſerved ſomething at ſome diſtance from them, which they regarded as a ſea-monſter; but upon its approach, it was known to be Nicolas, whom they took into their ſhip. When they aſked him whither he was going in ſo ſtormy and rough a ſea, and at ſuch a diſtance from land, he ſhewed them a packet of letters, which he was carrying to one of the towns of Italy, exactly done up in a leather bag, in ſuch a manner as that they could not be wetted by the ſea. He kept them thus company for ſome time on their voyage, converſing, and aſking queſtions; and after eating

ing an hearty meal with them, he took his leave, and jumping into the ſea, purſued his voyage alone.

" In order to aid theſe powers of enduring in the deep, nature ſeemed to have aſſiſted him in a very extraordinary manner; for the ſpaces between his fingers and toes were webbed, as in a gooſe; and his cheſt became ſo very capacious, that he could take in at one inſpiration, as much breath as would ſerve him for an whole day.

" The account of ſo extraordinary a perſon did not fail to reach the king himſelf; who, actuated by the general curioſity, ordered that Nicolas ſhould be brought before him. It was no eaſy matter to find Nicolas, who generally ſpent his time in the ſolitudes of the deep; but at laſt, however, after much ſearching, he was found, and brought before his majeſty. The curioſity of this monarch had been long excited by the accounts he had heard of the bottom of the gulph of Charybdis; he now, therefore, conceived that it would be a proper opportunity to have more certain information. He therefore commanded our poor diver to examine the bottom of this dreadful whirlpool; and, as an incitement to his obedience, ordered a golden cup to be flung into it. Nicolas was not

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inſenſible of the danger to which he was expoſed; dangers beſt known only to himſelf; and he therefore preſumed to remonſtrate: but the hopes of the reward, the deſire of pleaſing the king, and the pleaſure of ſhewing his ſkill, at laſt prevailed. He inſtantly jumped into the gulph, and was ſwallowed as inſtantly up in its boſom. He continued for three quarters of an hour below; during which time, the king and his attendants remained upon ſhore, anxious for his fate; but he at laſt appeared, buffeting upon the ſurface, holding the cup in triumph in one hand, and making his way good among the waves with the other. It may be ſuppoſed he was received with applauſe, upon his arrival on ſhore: the cup was made the reward of his adventure; the king ordered him to be taken proper care of; and, as he was ſomewat fatigued and debilitated by his labour, after an hearty meal, he was put to bed, and permitted to refreſh himſelf by ſleeping.

" When his ſpirits were thus reſtored, he was again brought, to ſatisfy the curioſity with a narrative of the wonders he had ſeen; and his account was to the following effect. He would never, he ſaid, have obeyed the king's commands, had he been apprized of half the dangers that were before him.

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There were four things, he ſaid, that rendered the gulph dreadful, not only to men, but even to the fiſhes themſelves: firſt, the force of the water burſting up from the bottom, which require great ſtrength to reſiſt; ſecondly, the abruptneſs of the rocks, that on every ſide threatened deſtruction; thirdly, the force of the whirlpool, daſhing againſt thoſe rocks; and fourthly, the number and magnitude of the polypous fiſh, ſome of which appeared as large as a man, and which every where ſticking againſt the rocks, projected their fibrous arms to entangle him. Being aſked how he was able ſo readily to find the cup that had been thrown in, he replied, that it happened to be flung by the waves into the cavity of a rock, againſt which he himſelf was urged in his deſcent. This account, however, did not ſatisfy the king's curioſity: being requeſted to venture once more into the gulph for further diſcoveries, he at firſt refuſed; but the king, deſirous of having the moſt exact information poſſible of all things to be found in the gulph, repeated his ſollicitations; and, to give them ſtill greater weight, produced a larger cup than the former, and added alſo a purſe of gold. Upon theſe conſiderations, the unfortunate Peſſacola once again plunged into the whirlpool, and was never heard of more."

CHAP.

CHAP. XVIII.

A ſummary Account of the Mechanical Properties of Air.

HAVING deſcribed the earth and the ſea, we now aſcend into that fluid which ſurrounds them both; and which, in ſome meaſure, ſupports and ſupplies all animated nature. As upon viewing the bottom of the ocean from its ſurface, we ſee an infinity of animals moving therein, and ſeeking food; ſo were ſome ſuperior being to regard the earth at a proper diſtance, he might conſider us in the ſame light: he might, from his ſuperior ſtation, behold a number of buſy little beings, immerſed in the aerial fluid, that every where ſurrounds them, and ſedulouſly employed in procuring the means of ſubſiſtence. This fluid, though too fine for the groſs perception of its inhabitants, might, to his nicer organs of ſight, be very viſible; and, while he at once ſaw into its operations, he might ſmile at the varieties of human conjecture concerning it: he might readily diſcern, perhaps, the height above the ſurface of the earth to which this fluid atmoſphere reaches: he might exactly determine that peculiar form of its parts which gives it the ſpring or elaſticity with which it is endued: he might diſtinguiſh which of its

parts

parts were pure incorruptible air, and which only made for a little time to aſſume the appearance, ſo as to be quickly returned back to the element from whence it came. But as for us, who are immerſed at the bottom of this gulph, we muſt be contented with a more confined knowledge; and, wanting a proper point of proſpect, remain ſatisfied with a combination of the effects.

One of the firſt things, therefore, that our ſenſes informs us of, is, that although the air is too fine for our ſight, it is very obvious to our touch. Although we cannot ſee the wind contained in a bladder, we can very readily feel its reſiſtance; and though the hurricane may want colour, we often fatally experience that it does not want force. We have equal experience of the air's ſpring or elaſticity: the bladder, when preſſed, returns again, upon the preſſure being taken away; a bottle, when filled, often burſts, from the ſpring of air which is included.

So far the ſlighteſt experience reaches; but, by carrying experiment a little farther, we learn, that air alſo is heavy: a round glaſs veſſel being emptied of its air, and accurately weighed, has been found lighter than when it was weighed with the air in it. Upon computing the ſuperior weight of the full

full veſſel, a cubic foot of air is found to weigh ſomething more than an ounce.

From this experiment, therefore, we learn, that the earth, and all things upon its ſurface, are every where covered with a ponderous fluid, which riſing very high over our heads, muſt be proportionably heavy. For inſtance, as in the ſea, a man at the depth of twenty feet, ſuſtains a greater weight of water than a man at the depth of but ten feet; ſo will a man at the bottom of a valley have a greater weight of air over him, than a man on the top of a mountain.

From hence we may conclude, that we ſuſtain a very great weight of air; and although, like men walking at the bottom of the ſea, we cannot feel the weight which preſſes equally round us, yet the preſſure is not the leſs real. As in morals, we ſeldom know the bleſſings that ſurround us till we are deprived of them, ſo here we do not perceive the weight of the ambient fluid till a part of it is taken away. If, by any means, we contrive to take away the preſſure of the air from any one part of our bodies, we are ſoon made ſenſible of the weight upon the other parts. Thus, if we clap our hand upon the mouth of a veſſel from whence the air has been taken away, there will thus be air on one ſide, and none on the other;

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upon which, we ſhall inſtantly find the hand violently ſucked inwards, which is nothing more than the weight of the air upon the back of the hand that cruſhes it into the ſpace which is empty below.

As by this experiment, therefore, we perceive that the air preſſes with great weight upon every thing on the ſurface of the earth, ſo by other experiments we learn the exact weight with which it preſſes. Firſt, if the air be exhauſted out of any veſſel, a drinking-glaſs for inſtance*, and this veſſel be ſet with the mouth downwards in water, the water will riſe up into the empty ſpace, and fill the inverted glaſs; for the external air will, in this caſe, preſs up the water, where there is no weight to reſiſt; as, one part of a bed being preſſed, makes the other parts, that have no weight upon them, riſe. In this caſe, therefore, as was ſaid, the water being preſſed without, will riſe in the glaſs; and would continue to riſe (if the empty glaſs were tall enough) thirty-two feet high. In fact, there have been pipes made purpoſely for this experiment, of above thirty-two feet high; in which, upon being exhauſted, the water has always riſen to the height of thirty-

* This may be done by burning a bit of paper in the ſame, and then quickly turning it down upon the water.

two

two feet: there it has always reſted, and never aſcended higher. From this, therefore, we learn, that the weight of the air which preſſes up the water, is equal to a pillar or column of water, which is thirty-two feet high; as it is juſt able to raiſe ſuch a column, and no more. In other words, the ſurface of the earth is every where covered with a weight of air, which is equivalent to a covering of thirty-two feet deep of water; or to a weight of twenty-nine inches and an half of quickſilver, which is known to be juſt as heavy as the former.

Thus, therefore, we ſee that the air at the ſurface of the earth is juſt as heavy as thirty-two feet of water, or twenty-nine inches and an half of quickſilver; and it is eaſily found, by computation, that to raiſe water thirty-two feet, will require a weight of fifteen pounds upon every ſquare inch. Now, if we are fond of computations, we have only to calculate how many ſquare inches are in the ſurface of an ordinary human body, and allowing every inch to ſuſtain fifteen pounds, we may amaze ourſelves at the weight of air we ſuſtain. It has been computed, and found, that our ordinary load of air amounts to within a little of forty thouſand pounds: this is wonderful! but wondering is not the way to grow wiſe.

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Notwithſtanding this be our ordinary load, and our uſual ſupply, there are at different times very great variations. The air is not, like water, equally heavy at all ſeaſons; but ſometimes is lighter, and ſometimes more heavy. It is ſometimes more compreſt, and ſometimes more elaſtic or ſpringy, which produces the ſame effects as an encreaſe of its weight. The air which at one time raiſes water thirty-two feet in the tube, and quickſilver twenty-nine inches, will not at another raiſe the one to thirty feet, or the other to twenty-ſix inches. This makes, therefore, a very great difference in the weight we ſuſtain; and we are actually known, by computation, to carry at one time four thouſand pounds of air more than at another.

The reaſon of this ſurprizing difference in the weight of air, is either owing to its preſſure from above, or to an encreaſe of vapour floating in it. Its encreaſed preſſure is the conſequence of its ſpring or elaſticity, which cold and heat ſenſibly affect, and are continually changing.

This elaſticity of the air is one of its moſt amazing properties; and to which it ſhould ſeem nothing can ſet bounds. A body of air that may be contained in a nut-ſhell, may eaſily, with heat, be dilated into a ſphere of unknown dimenſions. On the contrary, the

the air contained in an houſe, may be compreſſed into a cavity not larger than the eye of a needle. In ſhort, no bounds can be ſet to its confinement or expanſion; at leaſt, experiment has hitherto found its attempts indefinite. In every ſituation, it retains its elaſticity; and the more cloſely we compreſs it, the more ſtrongly does it reſiſt the preſſure. If to the encreaſing the elaſticity on one ſide by compreſſion, we encreaſe it on the other ſide by heat, the force of both ſoon becomes irreſiſtible; and a certain French philoſopher ſuppoſed *, that air thus confined, and expanding, was ſufficient for the exploſion of a world.

Many inſtruments have been formed to meaſure and determine theſe different properties of the air; and which ſerve ſeveral uſeful purpoſes. The barometer ſerves to meaſure its weight; to tell us when it is heavier, and when lighter. It is compoſed of a glaſs tube or pipe, of about thirty inches in length, cloſed up at one end; this tube is then filled with quickſilver; this done, the maker clapping his finger upon the open end, inverts the tube, and plunges the open end, finger and all, into a baſon of quickſilver, and then takes his finger away: now the quickſilver in the tube will, by its own weight,

* Monſieur Amontons.

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endeavour to deſcend into that in the baſon; but the external air, preſſing on the ſurface of the quickſilver in the baſon without, and no air being in the tube at top, the quick-ſilver will continue in the tube, being preſſed up, as was ſaid, by the air, on the ſurface of the baſon below. The height at which it is known to ſtand in the tube, is uſually about twenty-nine inches, when the air is heavy; but not above twenty-ſix, when the air is very light. Thus, by this inſtrument we can, with ſome exactneſs, determine the weight of the air; and, of conſequence, tell before-hand the changes of the weather. Before fine dry weather, the air is charged with a variety of vapours, which float in it unſeen, and render it extremely heavy, ſo that it preſſes up the quickſilver; or, in other words, the barometer riſes. In moiſt, rainy weather, the vapours are waſhed down, or there is not heat ſufficient for them to riſe, ſo that the air is then ſenſibly lighter, and preſſes up the quickſilver with leſs force; or in other words, the barometer is ſeen to fall. Our conſtitutions ſeem alſo to correſpond with the changes of the weather-glaſs; they are braced, ſtrong, and vigorous, with a large body of air upon them; they are languid, relaxed, and feeble, when the air is

light, and refuſes to give our fibres their proper tone.

But although the barometer thus meaſures the weight of the air with exactneſs enough for the general purpoſes of life, yet it is often affected with a thouſand irregularities, that no exactneſs in the inſtrument can remedy, and no theory account for. When high winds blow, the quickſilver generally is low: it riſes higher in cold weather, than in warm; and is uſually higher at morning and evening, than at mid-day: it generally deſcends lower after rain than it was before it. There are alſo frequent changes in the air, without any ſenſible alteration in the barometer.

As the barometer is thus uſed in predicting the changes of the weather, ſo it is alſo ſerviceable in meaſuring the heights of mountains, which mathematicians cannot ſo readily do: for, as the higher we aſcend from the ſurface of the earth, the air becomes lighter, ſo the quickſilver in the barometer will deſcend in proportion. It is found to ſink at the rate of the tenth part of an inch for every ninety feet we aſcend; ſo that in going up a mountain, if I find the quickſilver fallen an inch, I conclude, that I am got upon an aſcent of near nine hundred feet high. In this there has been found ſome

variation;

variation; into a detail of which, it is not the buſineſs of a natural hiſtorian to enter.

In order to determine the elaſticity of air, the wind-gun has been invented, which is an inſtrument variouſly made; but in all upon the principle of compreſſing a large quantity of air into a tube, in which there is an ivory ball, and then giving the compreſſed elaſtic air free power to act, and drive the ball as directed. The ball thus driven, will pierce a thick board: and will be as fatal, at ſmall diſtances, as if driven with gunpowder. I do not know whether ever the force of this inſtrument has been aſſiſted by means of heat; certain I am, that this, which could be very eaſily contrived by means of phoſphorus, or any other hot ſubſtance applied to the barrel, would give ſuch a force as I doubt whether gunpowder itſelf could produce.

The air-pump is an inſtrument contrived to exhauſt the air from round a veſſel adapted to that purpoſe, called a receiver. This method of exhauſting, is contrived in the ſimple inſtrument, by a piſton, like that of a ſyringe, going down into the veſſel, and thus puſhing out its air; which, by means of a valve, is prevented from returning into the veſſel again. But this, like all other complicated inſtruments, will be better under-

ſtood by a minute inſpection, than an hour's deſcription: it may ſuffice here to obſerve, that by depriving animals, and other ſubſtances, of all air, it ſhews us what the benefits and effects of air are in ſuſtaining life, or promoting vegetation.

The digeſter is an inſtrument of ſtill more extraordinary effects than any of the former; and ſufficiently diſcovers the amazing force of air, when its elaſticity is augmented by fire. A common tea-kettle, if the ſpout was cloſed up, and the lid put firmly down, would ſerve to become a digeſter, if ſtrong enough. But the inſtrument uſed for this purpoſe, is a ſtrong metal pot, with a lid to ſcrew cloſe on, ſo that, when down, no air can get in or return: into this pot, meat and bones are put, with a ſmall quantity of water, and then the lid ſcrewed cloſe: a lighted lamp is put underneath, and, what is very extraordinary, (yet equally true) in ſix or eight minutes the whole maſs, bones and all, are diſſolved into a jelly; ſo great is the force and elaſticity of the air contained within; ſtruggling to eſcape, and breaking in pieces all the ſubſtances with which it is mixed. Care, however, muſt be taken not to heat this inſtrument too violently; for then, the incloſed air would become irreſiſtible, and burſt the whole, with perhaps a fatal exploſion.

There

There are numberleſs other uſeful inſtruments made to depend on the weight, the elaſticity, or the fluidity of the air, which do not come within the plan of the preſent work; the deſign of which is not to give an account of the inventions that have been made for determining the nature and properties of air, but a mere narrative of its effects. The deſcription of the pump, the forcing pump, the fire engine, the ſteam engine, the ſyphon, and an hundred others, belong not to the naturaliſt, but the experimental philoſopher: the one gives an hiſtory of Nature, as he finds ſhe preſents herſelf to him; and he draws the obvious picture: the other, purſues her with cloſe inveſtigation, tortures her by experiment to give up her ſecrets, and meaſures her latent qualities with laborious preciſion. Much more, therefore, might be ſaid of the mechanical effects of air, and of the conjectures that have been made reſpecting the form of its parts; how ſome have ſuppoſed them to reſemble little hoops, coil'd up in a ſpring; others, like fleeces of wool; others, that the parts are endued with a repulſive quality, by which, when ſqueezed together, they endeavour to fly off, and recede from each other. We might have given the diſputes relative to the

height

height to which this body of air extends above us, and concerning which there is no agreement. We might have enquired how much of the air we breathe is elementary, and not reducible to any other ſubſtance; and of what denſity it would become, if it were ſuppoſed to be continued down to the centre of the earth. At that place we might, with the help of figures, and a bold imagination, have ſhewn it twenty thouſand times heavier than its bulk of gold. We might alſo prove it millions of times purer than upon earth, when raiſed to the ſurface of the atmoſphere. But theſe ſpeculations do not belong to natural hiſtory; and they have hitherto produced no great advantages in that branch of ſcience to which they more properly appertain.

CHAP. XIX.

An Eſſay towards a Natural Hiſtory of the Air.

A LATE eminent philoſopher has conſidered our atmoſphere as one large chymical veſſel, in which an infinite number of various operations are conſtantly performing. In it all the bodies of the earth are continually ſending up a part of their ſubſtance by evaporation, to mix in this great alembic, and to float a-while in common. Here minerals, from their loweſt depths, aſcend in noxious, or in warm vapours, to make a part of the general maſs; ſeas, rivers, and ſubterraneous ſprings, furniſh their copious ſupplies; plants receive and return their ſhare; and animals, that by living upon, conſume this general ſtore, are found to give it back in greater quantities, when they die *. The air, therefore, that we breathe, and upon which we ſubſiſt, bears very little reſemblance to that pure elementary body which was deſcribed in the laſt chapter; and which is rather a ſubſtance that may be conceived, than experienced to exiſt. Air, ſuch as we find it, is one of the moſt compounded bodies in all nature. Water may be reduced to a fluid every way

* Boyle, vol. ii. p. 593.

reſem-

reſembling air, by heat; which, by cold, becomes water again. Every thing that we ſee, gives off its parts to the air, and has a little floating atmoſphere of its own round it. The roſe is encompaſſed with a ſphere of its own odorous particles; while the night-ſhade infects the air with ſcents of a more ungrateful nature. The perfume of muſk flies off in ſuch abundance, that the quantity remaining, becomes ſenſibly lighter by the loſs. A thouſand ſubſtances that eſcape all our ſenſes, we know to be there; the powerful emanations of the load-ſtone, the effluvia of electricity, the rays of light, and the inſinuations of fire. Such are the various ſubſtances through which we move, and which we are conſtantly taking in at every pore, and returning again with imperceptible diſcharge.

This great ſolution, or mixture of all earthly bodies, is continually operating upon itſelf; which, perhaps, may be the cauſe of its unceaſing motion: but it operates ſtill more viſibly upon ſuch groſſer ſubſtances as are expoſed to its influence; for ſcarce any ſubſtance is found capable of reſiſting the corroding qualities of the air. The air, ſay the chymiſts, is a chaos, furniſhed with all kinds of ſalts and menſtruums; and, therefore, it is capable of diſſolving all kinds of bodies. It

is well known, that copper and iron are quickly covered, and eaten with ruſt; and that in the climates near the equator, no art can keep them clean. In thoſe dreary countries, the inſtruments, knives and keys, that are kept in the pocket, nevertheleſs are quickly encruſted; and the great guns, with every precaution, after ſome years, become uſeleſs. Stones, as being leſs hard, may be readily ſuppoſed to be more eaſily ſoluble. The marble of which the noble monuments of Italian antiquity are compoſed, although in one of the fineſt climates in the world, nevertheleſs ſhew the impreſſions which have been made upon them by the air. In many places they ſeem worm-eaten by time; and, in others, they appear crumbling into duſt. Gold alone ſeems to be exempted from this general ſtate of diſſolution; it is never found to contract ruſt, though expoſed ever ſo long: the reaſon of this ſeems to be, that ſea-ſalt, which is the only menſtruum capable of acting upon, and diſſolving gold, is but very little mixed with the air; for ſalt being a very fixed body, and not apt to volatilize, and riſe with heat, there is but a ſmall proportion of it in the atmoſphere. In the elaboratories, and ſhops, however, where ſalt is much uſed, and the air is impregnated with it, gold is found to ruſt as well as other metals.

Bodies

Bodies of a ſofter nature are obviouſly deſtroyed by the air *. Mr. Boyle ſays, that ſilks brought to Jamaica, will, if there expoſed to the air, rot even while they preſerve their colour; but if kept therefrom, they both retain their ſtrength and gloſs. The ſame happens in Braſil, where their cloaths, which are black, ſoon turn of an iron colour; though, in the ſhops, they preſerve their proper hue †. In theſe tropical climates alſo, ſuch are the putreſcent qualities of the air, that white ſugar will ſometimes be full of maggots. Drugs and plaiſters loſe their virtue, and become verminous. In ſome places they are obliged to expoſe their ſweetmeats by day in the ſun, otherwiſe the night air would quickly cauſe them to putrefy. On the contrary, in the cold arctic regions, animal ſubſtances, during their winter, are never known to putrefy; and meat may be kept for months, without any ſalt whatſoever. This experiment happily ſucceeded with the eight Engliſhmen that were accidentally left upon the inhoſpitable coaſts of Greenland, at a place where ſeven Dutchmen had periſhed but a few years before; for killing ſome reindeer for their ſubſiſtence, and having no ſalt to preſerve the fleſh, to their great ſurprize,

* Buffon, vol. iii. p. 62. † Ibid. vol. iii. p. 63.

they

they ſoon found it did not want any, as it remained ſweet during their eight months continuance upon that ſhore.

Theſe powers with which air is endued over unorganized ſubſtances, are exerted in a ſtill ſtronger manner over plants, animals of an inferior nature, and, laſtly, over man himſelf. Moſt of the beauty, and the luxuriance of vegetation, is well known to be derived from the benign influence of the air: and every plant ſeems to have its favourite climate, not leſs than its proper ſoil. The lower ranks of animals alſo, ſeem formed for their reſpective climates, in which only they can live. Man alone ſeems the child of every climate, and capable of exiſting in all. However, this peculiar privilege does not exempt him from the influences of the air; he is as much ſubject to its malignity, as the meaneſt inſect or vegetable.

With regard to plants, air is ſo abſolutely neceſſary for their life and preſervation, that they will not vegetate in an exhauſted receiver. All plants have within them a quantity of air, which ſupports and agitates their juices. They are continually imbibing freſh nutriment from the air, to encreaſe this ſtore, and to ſupply the wants which they ſuſtain from evaporation. When, therefore, the external

ternal air is drawn from them, they are no longer able to ſubſiſt. Even that quantity of air which they before were poſſeſſed of, eſcapes through their pores, into the exhauſted receiver; and as this continues to be pumped away, they become languid, grow flaccid, and die. However, the plant or flower thus ceaſing to vegetate, is kept, by being ſecured from the external air, a much longer time ſweet than it would have continued, had it been openly expoſed.

That air which is ſo neceſſary to the life of vegetables, is ſtill more ſo to that of animals; there are none found, how ſeemingly torpid ſoever, that do not require their needful ſupply. Fiſhes themſelves will not live in water from whence the air is exhauſted; and it is generally ſuppoſed that they die in frozen ponds, from the want of this neceſſary to animal exiſtence. Many have been the animals that idle curioſity has tortured in the priſon of a receiver, merely to obſerve the manner of their dying. We ſhall, from a thouſand inſtances, produce that of the viper, as it is known to be one of the moſt vivacious reptiles in the world; and as we ſhall feel but little compaſſion for its tortures. Mr. Boyle took a new caught viper, and ſhutting it up into a ſmall receiver, began to pump away the

the air *. "At firſt, upon the air's being drawn away, it began to ſwell; ſome time after he had done pumping, it began to gape, and open its jaws; being thus compelled to open its jaws, it once more reſumed its former lankneſs; it then began to move up and down within, as if to ſeek for air, and after a while foamed a little, having the foam ſticking to the inſide of the glaſs; ſoon after the body and neck grew prodigiouſly tumid, and a bliſter appeared upon its back; an hour and an half after the receiver was exhauſted, the diſtended viper moved, and gave manifeſt ſigns of life; the jaws remained diſtended; as it were from beneath the epiglottis, came the black tongue, and reached beyond it; but the animal ſeemed, by its poſture, not to have any life: the mouth alſo was growing blackiſh within; and in this ſituation it continued for twenty-three hours. But upon the air's being re-admitted, the viper's mouth was preſently cloſed, and ſoon after opened again; and for ſome time thoſe motions continued, which argued the remains of life." Such is the fate of the moſt inſignificant or minute reptile that can be thus included. Mites, fleas, and even the little eels that are found ſwimming in vinegar, die for want of air. Not only

* Boyle's Phiſic. Mechan. Exper. Paſſim.

theſe,

theſe, but the eggs of theſe animals, will not produce in vacuo, but require the air to bring them to perfection.

As in this manner air is neceſſary to their ſubſiſtence, ſo alſo it muſt be of a proper kind, and not impregnated with foreign mixtures. That factitious air which is pumped from plants or fluids, is generally, in a ſhort time, fatal to them. Mr. Boyle has given us many experiments to this purpoſe. After having ſhewn that all vegetable, and moſt mineral ſubſtances, properly prepared, may afford air, by being placed in an exhauſted receiver, and this in ſuch quantities, that ſome have thought it a new ſubſtance, made by the alteration which the mineral or plant has undergone by the texture of its parts being looſened in the operation—having ſhewn, I ſay, that this air may be drawn in great quantities from vegetable, animal, or mineral ſubſtances, ſuch as apples, cherries, amber burnt, or hartſhorn *—he included a frog in artificial air, produced from paſte; in ſeven minutes ſpace it ſuffered convulſions, and at laſt lay ſtill, and being taken out, recovered no motion at all, but was dead. A bird encloſed in artificial air, from raiſins, died in a quarter of a minute, and never ſtirred more. A ſnail was put into the receiver, with air of paſte; in four

* Boyle's Phyſic. Mechan. vol. ii. p. 598.

minutes

minutes it ceaſed to move, and was dead, altho' it had ſurvived in vacuo for ſeveral hours: ſo that factitious air proved a greater enemy to animals than even a vacuum itſelf.

Air alſo may be impregnated with fumes that are inſtantly fatal to animals. The fumes of hot iron, copper, or any other heated metal, blown into the place where an animal is confined, inſtantly deſtroy it. We have already mentioned the vapours in the grotto Del Cane ſuffocating a dog. The ancients even ſuppoſed, that theſe animals, as they always ran with their noſes to the ground, were the firſt that felt any infection. In ſhort, it ſhould ſeem that the predominance of any one vapour, from any body, how wholſome ſoever in itſelf, becomes infectious; and that we owe the ſalubrity of the air to the variety of its mixture.

But there is no animal whoſe frame is more ſenſibly affected by the change of the air than man. It is true, he can endure a greater variety of climates than the lower orders generally are able to do; but it is rather by the means which he has diſcovered of obviating their effects, than by the apparent ſtrength of his conſtitution. Moſt other animals can bear cold or hunger better, endure greater fatigues in proportion, and are ſatisfied with ſhorter repoſe.

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The variations of the climate, therefore, would probably affect them leſs, if they had the ſame means or ſkill in providing againſt the ſeverities of the change. However this be, the body of man is an inſtrument much more nicely ſenſible of the variations of the air, than any of thoſe which his own art has produced; for his frame alone ſeems to unite all their properties, being invigorated by the weight of the air, relaxed by its moiſture, enfeebled by its heat, and ſtiffened by its frigidity.

But it is chiefly by the predominance of ſome peculiar vapour, that the air becomes unfit for human ſupport. It is often found, by dreadful experience, to enter into the conſtitution, to mix with its juices, and to putrefy the whole maſs of blood. The nervous ſyſtem is not leſs affected by its operations; palſies and vertigoes are cauſed by its damps; and a ſtill more fatal train of diſtempers by its exhalations. In order that the air ſhould be wholſome, it is neceſſary, as we have ſeen, that it ſhould not be of one kind, but the compound of ſeveral ſubſtances; and the more various the compoſition, to all appearance the more ſalubrious. A man, therefore, who continues in one place, is not ſo likely to enjoy this wholſome variety, as he who changes his ſituation; and, if I may ſo expreſs it, inſtead

of

of waiting for a renovation of air, walks forward to meet its arrival. Thus mere motion, independent even of the benefits of exercise, becomes wholsome, by thus supplying a greater variety of that healthful fluid by which we are sustained.

A thousand accidents are found to encrease these bodies of vapour, that make one place more or less wholsome than another. Heat may raise them in too great quantities; and cold may stagnate them. Minerals may give off their effluvia in such proportion as to keep away all other kind of air; vegetables may render the air unwholsome by their supply; and animal putrefaction seems to furnish a quantity of vapour, at least as noxious as any of the former. All these united, generally make up the mass of respiration, and are, when mixed together, harmless; but any one of them, for a long time singly predominant, becomes at length fatal.

The effects of heat in producing a noxious quality in the air, are well known. Those torrid regions under the Line are always unwholsome. At Senegal, I am told, the natives consider forty as a very advanced time of life, and generally die of old age at fifty. At Carthagena *, in America, where the heat of the hottest day ever known in Europe is conti-

* Ulloa, vol. i. p. 42.

nual, where, during their winter ſeaſon, theſe dreadful heats are united with a continual ſucceſſion of thunder, rain, and tempeſts, ariſing from their intenſeneſs, the wan and livid complexions of the inhabitants might make ſtrangers ſuſpect that they were juſt recovered from ſome dreadful diſtemper; the actions of the natives are conformable to their colour; in all their motions there is ſomewhat relaxed and languid; the heat of the climate even affects their ſpeech, which is ſoft and ſlow, and their words generally broken. Travellers from Europe retain their ſtrength and ruddy colour in that climate, poſſibly for three or four months; but afterwards ſuffer ſuch decays in both, that they are no longer to be diſtinguiſhed from the inhabitants by their complexion. However, this languid and ſpiritleſs exiſtence is frequently drawled on ſometimes even to eighty. Young perſons are generally moſt affected by the heat of climate, which ſpares the more aged; but all, upon their arrival on the coaſts, are ſubject to the ſame train of fatal diſorders. Few nations have experienced the mortality of theſe coaſts, ſo much as our own: in our unſucceſsful attack upon Carthagena, more than three parts of our army were deſtroyed by the climate alone; and thoſe that returned from that fatal expedition, found

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their former vigour irretrievably gone. In our more fortunate expedition, which gave us the Havannah, we had little reaſon to boaſt of our ſucceſs; inſtead of a third, not a fifth part of the army were left ſurvivors of their victory, the climate being an enemy that even heroes cannot conquer.

The diſtempers that thus proceed from the malignity of thoſe climates, are many: that, for inſtance, called the Chapotonadas, carries off a multitude of people; and extremely thins the crews of European ſhips, whom gain tempts into thoſe inhoſpitable regions. The nature of this diſtemper is but little known, being cauſed in ſome perſons by cold, in others by indigeſtion. But its effects are far from being obſcure; it is generally fatal in three or four days: upon its ſeizing the patient, it brings on what is there called the black vomit, which is the ſad ſymptom after which none are ever found to recover. Some, when the vomit attacks them, are ſeized with a delirium, that, were they not tied down, they would tear themſelves to pieces, and thus expire in the midſt of this furious paroxyſm. This diſorder, in milder climates, takes the name of the bilious fever, and is attended with milder ſymptoms, but very dangerous in all.

There are many other diſorders incident to the human body, that ſeem the offspring of heat; but to mention no other, that very laſſitude which prevails in all the tropical climates, may be conſidered as a diſeaſe. The inhabitants of India *, ſays a modern philoſopher, ſuſtain an unceaſing languor, from the heats of their climate; and are torpid in the midſt of profuſion. For this reaſon, the great Diſpoſer of Nature has cloathed their country with trees of an amazing height, whoſe ſhade might defend them from the beams of the ſun; and whoſe continual freſhneſs might, in ſome meaſure, temperate their fierceneſs. From theſe ſhades, therefore, the air receives refreſhing moiſture, and animals a cooling protection. The whole race of ſavage animals retire, in the midſt of the day, to the very center of the foreſts, not ſo much to avoid their enemy man, as to find a defence againſt the raging heats of the ſeaſon. This advantage which ariſes from ſhade in torrid climates, may probably afford a ſolution for that extraordinary circumſtance related by Boyle, which he imputes to a different cauſe. In the iſland of Ternate, belonging to the Dutch, a place that had been long celebrated for its beauty and healthfulneſs, the clove trees grew in ſuch plenty, that they in ſome

* Linnæi Amœnitates, vol. v. p. 444.

mea-

meaſure leſſened their own value: for this reaſon, the Dutch reſolved to cut down the foreſts, and thus to raiſe the price of the commodity: but they had ſoon reaſon to repent of their avarice; for ſuch a change enſued, by cutting down the trees, that the whole iſland, from being healthy and delightful, having loſt its charming ſhades, became extremely ſickly, and has actually continued ſo to this day. Boerhaave conſidered heat ſo prejudicial to health, that he was never ſeen to go near a fire.

An oppoſite ſet of calamities are the conſequence, in climates where the air is condenſed by cold. In ſuch places, all that train of diſtempers which are known to ariſe from obſtructed perſpiration, are very common *; eruptions, boils, ſcurvy, and a loathſome leproſy, that covers the whole body with a ſcurf, and white putrid ulcers. Theſe diſorders alſo, are infectious; and, while they thus baniſh the patient from ſociety, they generally accompany him to the grave. The men of thoſe climates ſeldom attain to the age of fifty; but the women, who do not lead ſuch laborious lives, are found to live longer.

The autumnal complaints which attend a wet ſummer, indicate the dangers of a moiſt

* Krantz's Hiſtory of Greenland, vol. i. p. 235.

air.

air. The long continuance of an eaſt wind alſo, ſhews the prejudice of a dry one. Mineral exhalations, when copious, are every where known to be fatal; and although we probably owe the encreaſe and luxuriance of vegetation to a moderate degree of their warmth, yet the natives of thoſe countries where there are mines in plenty, but too often experience the noxious effects of their vicinity. Thoſe trades alſo that deal in the preparations of metals of all kinds, are always unwholſome; and the workmen, after ſome time, are generally ſeen to labour under palſies, and other nervous complaints. The vapours from ſome vegetable ſubſtances, are well known to be attended with dangerous effects. The ſhade of the machinel tree, in America, is ſaid to be fatal; as was that of the juniper, if we may credit the ancients. Thoſe who walk through fields of poppies, or in any manner prepare thoſe flowers for making opium, are very ſenſibly affected with the drowſineſs they occaſion. A phyſician of Mr. Boyle's acquaintance, cauſing a large quantity of black hellebore to be pounded in a mortar, moſt of the perſons who were in the room, and eſpecially the perſon who pounded it, were purged by it, and ſome of them ſtrongly. He alſo gathered a certain plant in Ireland, which the perſon who beat

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in a mortar, and the phyſician who was ſtanding near, were ſo ſtrongly affected by, that their hands and faces ſwelled to an enormous ſize, and continued tumid for a long time after.

But neither mineral nor vegetable ſteams are ſo dangerous to the conſtitution, as thoſe proceeding from animal ſubſtances, putrefying either by diſeaſe or death. The effluvia that comes from diſeaſed bodies, propagate that frightful catalogue of diſorders which are called infectious. The parts which compoſe vegetable vapours, and mineral exhalations, ſeem groſs and heavy, in compariſon of theſe volatile vapours, that go to great diſtances, and have been deſcribed as ſpreading deſolation over the whole earth. They fly every where; penetrate every where; and the vapours that fly from a ſingle diſeaſe, ſoon render it epidemic.

The plague is the firſt upon the liſt in this claſs of human calamities. From whence this ſcourge of man's preſumption may have its beginning, is not well known; but we well know that it is propagated by infection. Whatever be the general ſtate of the atmoſphere, we learn, from experience, that the noxious vapours, though but ſingly introduced at firſt, taints the air by degrees: every perſon infected, tends to add to the growing malignity; and, as the diſorder becomes more

general, the putrefcence of the air becomes more noxious, fo that the fymptoms are aggravated by continuance. When it is faid that the origin of this diforder is unknown, it implies, that the air feems to be but little employed in firft producing it. There are fome countries, even in the midft of Africa, that we learn have never been infected with it; but continue, for centuries, unmolefted. On the contrary, there are others, that are generally vifited once a year, as in Egypt, which, nevertheleſs, ſeems peculiarly bleſſed with the ſerenity and temperature of its climate. In the former countries, which are of vaſt extent, and many of them very populous, every thing ſhould ſeem to diſpoſe the air to make the plague continual among them. The great heats of the climate, the unwholſomeneſs of the food, the ſloth and dirt of the inhabitants, but, above all, the bloody battles which are continually fought among them, after which heaps of dead bodies are left unburied, and expoſed to putrefaction. All theſe one might think would be apt to bring the plague among them; and yet, nevertheleſs, we are aſſured by Leo Africanus, that in Numidia the plague is not known once in an hundred years; and that in Negroland, it is not known at all. This dreadful diſorder, therefore, muſt have its riſe, not

from

from any previous diſpoſition of the air, but from ſome particular cauſe, beginning with one individual, and extending the malignity, by communication, till at laſt the air becomes actually tainted by the generality of the infection.

The plague which ſpread itſelf over the whole world, in the year 1346, as we are told by Mezeray, was ſo contagious, that ſcarce a village, or even an houſe, eſcaped being infected by it. Before it had reached Europe, it had been for two years travelling from the great kingdom of Cathay, where it began by a vapour moſt horridly fœtid; this broke out of the earth like a ſubterranean fire, and upon the firſt inſtant of its eruption, conſumed and deſolated above two hundred leagues of that country, even to the trees and ſtones.

In that great plague which deſolated the city of London, in the year 1665, a pious and learned ſchoolmaſter of Mr. Boyle's acquaintance, who ventured to ſtay in the city, and took upon him the humane office of viſiting the ſick and the dying, who had been deſerted by better phyſicians, averred, that being once called to a poor woman who had buried her children of the plague, he found the room where ſhe lay ſo little, that it ſcarce could hold any more than the bed

whereon

whereon ſhe was ſtretched. However, in this wretched abode, beſide her, in an open coffin, her huſband lay, who had ſome time before died of the ſame diſeaſe; and whom ſhe, poor creature, ſoon followed. But what ſhewed the peculiar malignity of the air thus ſuffering from animal putrefaction, was, that the contagious ſteams had produced ſpots on the very wall of their wretched apartment: and Mr. Boyle's own ſtudy, which was contiguous to a peſt-houſe, was alſo ſpotted in the ſame frightful manner. Happily for mankind, this diſorder, for more than a century, has not been known in our iſland; and, for this laſt age, has abated much of its violence, even in thoſe countries where it is moſt common. Diſeaſes, like empires, have their revolutions; and thoſe which for a while were the ſcourge of mankind, ſink unheard of, to give place to new ones, more dreadful, as being leſs underſtood.

For this revolution in diſorders, which has employed the ſpeculation of many, Mr. Boyle accounts in the following manner. "Since," ſays he, "there want not cauſes in the bowels of the earth, to make conſiderable changes amongſt the materials that nature has plentifully treaſured up in thoſe magazines, and as thoſe noxious ſteams are abundantly ſupplied to the ſurface, it may not

ſeem

ſeem improbable, that in this great variety, ſome may be found capable of particularly affecting the human frame in a particular manner, and thus of producing new diſeaſes. The duration of theſe may be greater or leſs, according to the laſtingneſs of thoſe ſubterraneous cauſes that produced them. On which account, it need be no wonder that ſome diſeaſes have but a ſhort duration, and vaniſh not long after they appear; whilſt others may continue longer, as having under ground more ſettled and durable cauſes to maintain them."

From the recital of this train of miſchiefs produced by the air, upon minerals, plants, animals, and man himſelf, a gloomy mind may be apt to dread this indulgent nurſe of nature as a cruel and an inexorable ſtepmother: but it is far otherwiſe; and, although we are ſometimes injured, yet almoſt all the comforts and bleſſings of life ſpring from its propitious influence. It would be needleſs to obſerve, that it is abſolutely neceſſary for the ſupport of our lives; for of this, every moment's experience aſſures us. But how it contributes to this ſupport, is not ſo readily comprehended. All allow it to be a friend, to whoſe benefits we are conſtantly obliged: and yet, to this hour, philoſophers are divided as to the nature of the obligation.

tion. The diſpute is, whether the air is only uſeful by its weight to force our juices into circulation*; or, whether, by containing a peculiar ſpirit, it mixes with the blood in our veſſels, and acts like a ſpur to their induſtry†. Perhaps it may exert both theſe uſeful offices at the ſame time. Its weight may give the blood its progreſſive motion, through the larger veſſels of the body; and its admixture with it, cauſe thoſe contractions of all the veſſels, which ſerve to force it ſtill more ſtrongly forward, through the minuteſt channels of the circulation. Be this as it may, it is well known, that that part of our blood which has juſt received the influx of the air in our bodies, is of a very different colour from that which has almoſt performed its circuit. It has been found, that the arterial blood which has been immediately mixed with the air in the lungs, and, if I may ſo expreſs it, is juſt beginning its journey through the body, is of a fine florid ſcarlet colour; while, on the contrary, the blood of the veins that is returning from having performed its duty, is of a blackiſh crimſon hue. Whence this difference of colour ſhould proceed, is not well underſtood; we only know the fact, that this

* Keil. Robinſon.

† Whytt upon vital and involuntary Motions.

florid

florid colour is communicated by the air; and we are well convinced, that this air has been admitted into the blood for very uſeful purpoſes.

Beſides this vital principle in animals, the air alſo gives life and body to flame. A candle quickly goes out in an exhauſted receiver; for having ſoon conſumed the quantity of air, it then expires, for want of a freſh ſupply. There has been a flame contrived that will burn under water; but none yet has been found, that will continue to burn without air. Gunpowder, which is the moſt catching and powerful fire we know, will not go off in an exhauſted receiver; nay, if a train of gunpowder be laid, ſo as that one part may be fired in the open air, yet the other part in vauco will remain untouched, and unconſumed. Wood alſo ſet on fire, immediately goes out; and its flame ceaſes upon removing the air; for ſomething is then wanting to preſs the body of the fire againſt that of the fuel, and to prevent the too ſpeedy diffuſion of the flame. We frequently ſee cooks, and others, whoſe buſineſs it is to keep up ſtrong fires, take proper precautions to exclude the beams of the ſun from ſhining upon them, which effectually put them out. This they are apt to aſcribe to a wrong cauſe; namely, the

operation

operation of the light: but the real fact is, that the warmth of the ſun-beams leſſens and diſſipates the body of the air that goes to feed the flame; and the fire, of conſequence, languiſhes for want of a neceſſary ſupply.

The air, while it thus kindles fire into flame, is notwithſtanding found to moderate the rays of light, to diſſipate their violence, and to ſpread an uniform luſtre over every object. Were the beams of the ſun to dart directly upon us, without paſſing through this protecting medium, they would either burn us up at once, or blind us with their effulgence. But by going through the air, they are reflected, refracted, and turned from their direct courſe, a thouſand different ways; and thus are more evenly diffuſed over the face of nature.

Among the other neceſſary benefits the air is of to us, one of the principal is its conveyance of ſound. Even the vibrations of a bell, which have the loudeſt effect that we know of, ceaſe to be heard, when under the receiver of an air-pump. Thus all the pleaſures we receive from converſation with each other, or from muſic, depend entirely upon the air.

Odours likewiſe are diffuſed only by the means of air; without this fluid to ſwim in, they would for ever remain torpid in their

reſpective

reſpective ſubſtances; and the roſe would affect us with as little ſenſations of pleaſure, as the thorn on which it grew.

Thoſe who are willing to augment the catalogue of the benefits we receive from this element, aſſert alſo, that taſtes themſelves would be inſipid, were it not that the air preſſes their parts upon the nerves of the tongue and palate, ſo as to produce their grateful effects. Thus, continue they, upon the tops of high mountains, as on the Pike of Teneriff, the moſt poignant bodies, as pepper, ginger, ſalt, and ſpice, have no ſenſible taſte, for want of their particles being thus ſent home to the ſenſory. But, we owe the air ſufficient obligations, not to be ſtudious of admitting this among the number: in fact, all ſubſtances have their taſtes, as well on the tops of mountains, as in the bottom of the valley; and I have been one of many, who have eat a very ſavoury dinner on the Alps.

It is ſufficient, therefore, that we regard the air as the parent of health and vegetation; as a kind diſpenſer of light and warmth; and as the conveyer of ſounds and odours. This is an element of which avarice will not deprive us; and which power cannot monopolize. The treaſures of the earth, the verdure of the fields, and even

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the refreſhments of the ſtream, are too often ſeen going only to aſſiſt the luxuries of the great; while the leſs fortunate part of mankind ſtand humble ſpectators of their encroachments. But the air no limitations can bound, nor any land-marks reſtrain. In this benign element, all mankind can boaſt an equal poſſeſſion; and for this we all have equal obligations to Heaven. We conſume a part of it, for our own ſuſtenance, while we live; and, when we die, our putrefying bodies give back the ſupply, which, during life, we had accumulated from the general maſs.

CHAP. XX.

Of Winds, irregular and regular.

WIND is a current of air. Experimental philoſophers produce an artificial wind, by an inſtrument called an aeolipile. This is nothing more than an hollow copper ball, with a long pipe; a tea-kettle might be readily made into one, if it were entirely cloſed at the lid, and the ſpout left open; through this ſpout it is to be filled with water, and then ſet upon the fire, by which means it produces a violent blaſt, like wind, which continues while there is any water remaining in the inſtrument. In this manner water is converted into a ruſhing air; which, if caught as it goes out, and left to cool, is again quickly converted into its former element. Beſides this, as was mentioned in the former chapter, almoſt every ſubſtance contains ſome portions of air. Vegetables, or the bodies of animals left to putrefy, produce it in a very copious manner. But it is not only ſeen thus eſcaping from bodies, but it may be very eaſily made to enter into them. A quantity of air may be compreſſed into water, ſo as to be intimately blended with it. It finds a much eaſier admiſſion into wine, or any fermented liquor;

and an eaſier ſtill, into ſpirits of wine. Some ſalts ſuck up the air in ſuch quantities, that they are made ſenſibly heavier thereby, and often are melted by its moiſture. In this manner, moſt bodies, being found either capable of receiving or affording it, we are not to be ſurprized at thoſe ſtreams of air that are continually fleeting round the globe. Minerals, vegetables, and animals, contribute to encreaſe the current; and are ſending off their conſtant ſupplies. Theſe, as they are differently affected by cold or heat, by mixture or putrefaction, all yield different quantities of air at different times; and the loudeſt tempeſts, and moſt rapid whirlwinds, are formed from their united contributions.

The ſun is the principal inſtrument in rarefying the juices of plants, ſo as to give an eſcape to their impriſoned air; it is alſo equally operative in promoting the putrefaction of animals. Mineral exhalations are more frequently raiſed by ſubterranean heat. The moon, the other planets, the ſeaſons, are all combined in producing theſe effects in a ſmaller degree. Mountains give a direction to the courſes of the air. Fires carry a current of air along their body. Night and day alternately chill and warm the earth, and produce an alternate current of vapours. Theſe, and an hundred other

cauſes,

cauſes, may be aſſigned for the variety, and the activity of the winds, their continual change, and uncertain duration.

With us on land, therefore, as the wind proceeds from ſo many cauſes, and meets ſuch a variety of obſtacles, there can be but little hopes of ever bringing its motions to conform to theory; or of foretelling how it may blow a minute to come. The great Bacon, indeed, was of opinion, that by a cloſe and regular hiſtory of the winds, continued for a number of ages together, and the particulars of each obſervation reduced to general maxims, we might at laſt come to underſtand the variations of this capricious element; and that we could foretell the certainty of a wind, with as much eaſe as we now foretell the return of an eclipſe. Indeed, his own beginnings in this arduous undertaking, ſeem to ſpeak the poſſibility of its ſucceſs; but, unhappily for mankind, this inveſtigation is the work of ages, and we want a Bacon to direct the proceſs.

To be able, therefore, with any plauſibility, to account for the variations of the wind upon land, is not to be at preſent expected; and to underſtand any thing of their nature, we muſt have recourſe to thoſe places where they are more permanent and ſteady. This uniformity and ſteadineſs we

are chiefly to expect upon the ocean. There, where there is no variety of ſubſtances to furniſh the air with various and inconſtant ſupplies, where there are no mountains to direct the courſe of its current, but where all is extenſively uniform and even; in ſuch a place, the wind ariſing from a ſimple cauſe, muſt have but one ſimple motion. In fact, we find it ſo. There are many parts of the world where the winds, that with us are ſo uncertain, pay their ſtated viſits. In ſome places, they are found to blow one way by day, and another by night; in others, for one half of the year, they go in a direction contrary to their former courſe: but what is more extraordinary ſtill, there are ſome places where the winds never change, but for ever blow the ſame way. This is particularly found to obtain between the tropics in the Atlantic and Æthiopic oceans; as well as in the great Pacific ſea.

Few things ſurely can appear more extraordinary to a perſon who has never been out of our variable latitudes, than this ſteady wind, that for ever ſits in the ſail, ſending the veſſel forward; and as effectually preventing its return. He who has been taught to conſider that nothing in the world is ſo variable as the winds, muſt certainly be ſurprized to find a place where there is nothing

nothing more uniform. With us their inconſtancy has become a proverb; with the natives of thoſe diſtant climates, they may talk of a friend or a miſtreſs as fixed and unchangeable as the winds, and mean a compliment by the compariſon. When our ſhips are once arrived into the proper latitudes of the great Pacific ocean, the mariner forgets the helm, and his ſkill becomes almoſt uſeleſs: neither ſtorms nor tempeſts are known to deform the glaſſy boſom of that immenſe ſheet of waters; a gentle breeze, that for ever blows in the ſame direction, reſts upon the canvas, and ſpeeds the navigator. In the ſpace of ſix weeks, ſhips are thus known to croſs an immenſe ocean, that takes more than ſo many months to return. Upon returning, the trade-wind, which has been propitious, is then avoided; the mariner is generally obliged to ſteer into the northern latitudes, and to take the advantage of every caſual wind that offers, to aſſiſt him into port. This wind, which blows with ſuch conſtancy one way, is known to prevail not only in the Pacific ocean, but alſo in the Atlantic, between the coaſts of Guinea and Brazil; and, likewiſe, in the Æthiopic ocean. This ſeems to be the great univerſal wind, blowing from the eaſt to the weſt, that prevails in all the extenſive

extenſive oceans, where the land does not frequently break the general current. Were the whole ſurface of the globe an ocean, there would probably be but this one wind, for ever blowing from the eaſt, and purſuing the motions of the ſun weſtward. All the other winds ſeem ſubordinate to this; and many of them are made from the deviations of its current. To form, therefore, any conception relative to the variations of the wind in general, it is fitteſt to begin with that which never varies.

There have been many theories to explain this invariable motion of the winds; among the reſt, we cannot omit that of Doctor Lyſter, for its ſtrangeneſs. "The ſea," ſays he, "in thoſe latitudes, is generally covered over with green weeds, for a great extent; and the air produced from the vegetable perſpiration of theſe, produces the trade-wind." The theory of Carteſius was not quite ſo abſurd. He alledged, that the earth went round faſter than its atmoſphere at the equator; ſo that its motion, from weſt to eaſt, gave the atmoſphere an imaginary one from eaſt to weſt; and thus an eaſt-wind was eternally ſeen to prevail. Rejecting thoſe arbitrary opinions, conceived without force, and aſſerted without proof, Doctor Halley has given one more plauſible; which

which ſeems to be the reigning ſyſtem of the day.

To conceive his opinion clearly, let us for a moment ſuppoſe the whole ſurface of the earth to be an ocean, and the air encompaſſing it on every ſide, without motion. Now it is evident, that that part of the air that lies directly under the beams of the ſun, will be rarefied; and if the ſun remained for ever in the ſame place, there would be a great vacuity in the air, if I may ſo expreſs it, beneath the place where the ſun ſtood. But the ſun moving forward, from eaſt to weſt, this vacuity will follow too, and ſtill be made under it. But while it goes on to make new vacuities, the air will ruſh in to fill up thoſe the ſun has already made; in other words, as it is ſtill travelling forward, the air will continually be ruſhing in behind, and purſue its motions from eaſt to weſt. In this manner, the air is put into motion by day; and by night, the parts continue to impel each other, till the next return of the ſun, that gives a new force to the circulation.

In this manner is explained the conſtant eaſt-wind that is found blowing round the globe, near the equator. But it is alſo known, that as we recede from the equator on either ſide, we come into a trade-wind, that

that continually blows from the poles, from the north on one ſide, or the ſouth on the other, both directing towards the equator. This alſo proceeds from a ſimilar cauſe with the former; for the air being more rarefied in thoſe places over which the ſun more directly darts its rays, the currents will come both from the north and the ſouth, to fill up the intermediate vacuity.

Theſe two motions, namely, the general one from eaſt to weſt, and the more particular one from both the Poles, will account for all the phænomena of trade-winds; which, if the whole ſurface of the globe were ſea, would undoubtedly be conſtant, and for ever continue to blow in one direction. But there are a thouſand circumſtances to break theſe air-currents into ſmaller ones; to drive them back againſt their general courſe; to raiſe or depreſs them; to condenſe them into ſtorms; or to whirl them in eddies. In conſequence of this, regard muſt be often had to the nature of the ſoil, the poſition of the high mountains, the courſe of the rivers, and even to the luxuriance of vegetation.

If a country lying directly under the ſun, be very flat and ſandy, and if the land be low and extenſive, the heats occaſioned by the reflection of the ſun-beams, produces a very great rarefaction of the air. The deſarts

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of Africa which are conformable to this deſcription, are ſcarce ever fanned by a breath of wind by day; but the burning ſun is continually ſeen blazing in intolerable ſplendor above them. For this reaſon, all along the coaſts of Guinea, the wind is always perceived blowing in upon land, in order to fill up the vacuity cauſed by the ſun's operation. In thoſe ſhores, therefore, the wind blows in a contrary direction to that of its general current; and is conſtantly found ſetting in from the weſt.

From the ſame cauſe it happens, that thoſe conſtant calms, attended with deluges of rain, are found in the ſame part of the ocean. For this tract being placed in the middle, between the weſterly winds blowing on the coaſt of Guinea, and the eaſterly trade-winds that move at ſome diſtance from ſhore in a contrary direction, the tendency of that part of the air that lies between theſe two oppoſite currents, is indifferent to either, and ſo reſts between both in torpid ſerenity; and the weight of the incumbent atmoſphere, being diminiſhed by the continual contrary winds blowing from hence, it is unable to keep the vapours ſuſpended that are copiouſly borne thither; ſo that they fall in continual rains.

But it is not to be ſuppoſed, that any theo-

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ry can account for all the phænomena of even thoſe winds that are known to be moſt regular. Inſtead, therefore, of a complete ſyſtem of the trade-winds, we muſt rather be content with an imperfect hiſtory. Theſe *, as was ſaid, being the reſult of a combination of effects, aſſume as great a variety as the cauſes producing them are various.

Beſides the great general wind abovementioned, in thoſe parts of the Atlantic that lie under the temperate zone, a north wind prevails conſtantly during the months of October, November, December, and January. Theſe, therefore, are the moſt favourable months for embarking for the Eaſt-Indies, in order to take the benefit of theſe winds, for croſſing the line: and it has been often found, by experience, that thoſe who had ſet ſail five months before, were not in the leaſt farther advanced in their voyage, than thoſe who waited for the favourable wind. During the winter of Nova Zembla, and the other arctic countries, a north wind reigns almoſt continually. In the Cape de Verde iſlands, a ſouth wind prevails during the month of July. At the Cape of Good Hope, a north-weſt wind blows during the month of September. There are alſo regular winds, produced by various cauſes, upon land. The

* Buffon, vol. ii. p. 2,0.

ancient

ancient Greeks were the firſt who obſerved a conſtant breeze, produced by the melting of the ſnows, in ſome high neighbouring countries. This was perceived in Greece, Thrace, Macedonia, and the Ægean ſea. The ſame kind of winds are now remarked in the kingdom of Congo, and the moſt ſouthern parts of Africa. The flux and reflux of the ſea alſo produces ſome regular winds, that ſerve the purpoſes of trade; and, in general, it may be obſerved, that wherever there is a ſtrong current of water, there is a current of air that ſeems to attend it.

Beſide theſe winds that are found to blow in one direction, there are, as was ſaid before, others that blow for certain months of the year one way, and the reſt of the year the contrary way: theſe are called the Monſoons, from a famous pilot of that name, who firſt uſed them in navigation with ſucceſs *. In all that part of the ocean that lies between Africa and India, the eaſt winds begin at the month of January, and continue till about the commencement of June. In the month of Auguſt, or September, the contrary direction takes place; and the weſt winds prevail for three or four months. The interval between theſe winds, that is to ſay, from the end of June to the beginning of Au-

* Varenii Geographia Geurculis, cap. 20.

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guſt, there is no fixed wind; but the ſea is uſually toſſed by violent tempeſts, proceeding from the north. Theſe winds are always ſubject to their greateſt variations, as they approach the land; ſo that on one ſide of the great peninſula of India, the coaſts are, for near half the year, harraſſed by violent hurricanes, and northern tempeſts; while, on the oppoſite ſide, and all along the coaſts of Coromandel, theſe dreadful tempeſts are wholly unknown. At Java, and Ceylon, a weſt wind begins to reign in the month of September; but at fifteen days of ſouth latitude, this wind is found to be loſt, and the great general trade-wind from the eaſt, is perceived to prevail. On the contrary, at Cochin, in China, the weſt wind begins at March; ſo that theſe Monſoons prevail, at different ſeaſons, throughout the Indies. So that the mariner takes one part of the year to go from Java to the Moluccas; another from Cochin to Molucca; another from Molucca to China; and ſtill another to direct him from China to Japan.

There are winds alſo that may be conſidered as peculiar to certain coaſts; for example, the ſouth wind is almoſt conſtant upon the coaſts of Chili and Peru; weſtern winds almoſt conſtantly prevail on the coaſt of Ter-

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ra Magellanica; and in the environs of the Streights le Maire. On the coaſts of Malabar, north and north-weſt winds prevail continually; along the coaſt of Guinea, the north-weſt wind is alſo very frequent; and, at a diſtance from the coaſts, the north-eaſt is always found prevailing. From the beginning of November to the end of December, a weſt wind prevails on the coaſts of Japan; and, during the whole winter, no ſhips can leave the port of Cochin, on account of the impetuoſity of the winds that ſet upon the coaſt. Theſe blow with ſuch vehemence that the ports are entirely choaked up with ſand, and even boats themſelves are not able to enter. However, the eaſt winds that prevail for the other half of the year, clear the mouths of their harbours from the accumulations of the preceding winter, and ſet the confined ſhips at liberty. At the Streights of Babelmandel there is a ſouth wind that periodically returns, and which is always followed by a north-eaſt.

Beſide winds thus peculiar to certain coaſts, there are others found to prevail on all the coaſts, in warm climates; which, during one part of the day, blow from the ſhore, and, during another part of it, blow from the ſea. The ſea-breeze, in thoſe countries, as Dampier

pier obſerves, commonly riſes in the morning, about nine, proceeding ſlowly, in a fine ſmall black curl, upon the ſurface of the water, and making its way to refreſh the ſhore. It is gentle at firſt, but encreaſes gradually till twelve, then inſenſibly ſinks away, and is totally huſhed at five. Upon its ceaſing, the land-breeze begins to take its turn, which increaſes till twelve at night, and is ſucceeded, in the morning, by the ſea-breeze again. Without all doubt, nothing could have been more fortunate, for the inhabitants of the warm countries, where thoſe breezes blow, than this alternate refreſhment, which they feel at thoſe ſeaſons when it is moſt wanted. The heat, on ſome coaſts, would be inſupportable, were it not for ſuch a ſupply of air, when the ſun has rarefied all that which lay more immediately under the coaſt. The ſea-breeze temperates the heat of the ſun by day; and the land-breeze corrects the malignity of the dews, and vapours, by night. Where theſe breezes, therefore, prevail, and they are very common, the inhabitants enjoy a ſhare of health, and happineſs, unknown to thoſe that live much farther up the country, or ſuch as live in ſimilar latitudes without this advantage. The cauſe of theſe obviouſly ſeems to ariſe from the rarefaction of

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the air by the ſun, as their duration continues with its appearance, and alters when it goes down. The ſun, it is obſerved, equally diffuſing his beams upon land and ſea, the land, being a more ſolid body than the water, receives a greater quantity of heat, and reflects it more ſtrongly. Being thus, therefore, heated to a greater degree than the waters, it, of conſequence, drives the air from land out to ſea; but, its influence being removed, the air returns to fill up the former vacuity. Such is the uſual method of accounting for this phænomenon; but, unfortunately, theſe ſea and land breezes are viſitants that come at all hours. On the coaſts of Malabar *, the land-breezes begin at midnight, and continue till noon; then the ſea-breezes take their turn, and continue till midnight again. While, again, at Congo, the land-breezes begin at five, and continue till nine the next day.

But, if the cauſe of theſe be ſo inſcrutable, that are, as we ſee, tolerably regular in their viſitations, what ſhall we ſay to the winds of our own climate, that are continually ſhifting, and incapable of reſt? Some general cauſes may be aſſigned, which nothing but particular experience can apply. And, in the firſt

* Buffon, vol. ii. p. 252.

place,

place, it may be obſerved, that clouds, and heat, and, in ſhort, whatever either encreaſes the denſity or the elaſticity of the air, in any one place, will produce a wind there: for the encreaſed activity of the air thus preſſing more powerfully on the parts of it that are adjacent, will drive them forward, and thus go on, in a current, till the whole comes to an equality.

In this manner, as a denſer air produces a wind, on the one hand; ſo will any accident, that contributes to lighten the air, produce it on the other: for, a lighter air may be conſidered as a vacuity, into which the neighbouring air will ruſh: and hence it happens, that when the barometer marks a peculiar lightneſs in the air, it is no wonder that it foretells a ſtorm.

The winds upon large waters are generally more regular than thoſe upon land. The wind at ſea generally blows with an even ſteady gale; the wind at land puffs by intervals, encreaſing its ſtrength, and remitting it, without any apparent cauſe. This, in a great meaſure, may be owing to the many mountains, towers, or trees, that it meets in its way, all contributing either to turn it from its courſe, or interrupt its paſſage.

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The eaſt wind blows more conſtantly than any other, and for an obvious reaſon: all other winds are, in ſome meaſure, deviations from it, and partly may owe their origin thereto. It is generally, likewiſe, the moſt powerful, and for the ſame reaſon.

There are often double currents of the air. While the wind blows one way, we frequently ſee the clouds move another. This is almoſt ever the caſe before thunder; for it is well known that the thunder cloud always moves againſt the wind: the cauſe of this ſurprizing appearance has hitherto remained a ſecret. From hence we may conclude, that weathercocks only inform us of that current of the air, which is near the ſurface of the earth; but are often erroneous with regard to the upper regions; and, in fact, Derham has often found them erroneous.

Winds are generally more powerful on elevated ſituations than on the plain, becauſe their progreſs is interrupted by fewer obſtacles. In proportion as we aſcend the heights of a mountain, the violence of the weather ſeems to encreaſe, until we have got above the region of ſtorms, where all is uſually calm and ſerene. Sometimes, however, the ſtorms riſe even to the tops of the higheſt mountains; as we learn from thoſe who have been on the Andes, and as we

are convinced by the deep ſnows that crown even the higheſt.

Winds blowing from the ſea are generally moiſter, and more attended with rains, than thoſe which blow over extenſive tracts of land: for the ſea gives off more vapours to the air, and theſe are rolled forward upon land, by the winds blowing from thence *. For this reaſon our eaſterly winds, that blow from the continent, are dry, in compariſon of thoſe that blow from the ſurface of the ocean, with which we are ſurrounded on every other quarter.

In general the winds are more boiſterous in ſpring and autumn, than at other ſeaſons: for, that being the time of high tides, the ſea may communicate a part of its motions to the winds. The ſun, and moon, alſo, which then have a greater effect upon the waters, may alſo have ſome influence upon the winds; for, there being a great body of air ſurrounding the globe, which, if condenſed into water, would cover it to the depth of thirty-two feet, it is evident that the ſun and moon will, to a proportionable degree, affect the atmoſphere, and make a tide of air. This tide will be ſcarce perceivable, indeed; but, without doubt, it actually exiſts; and may contribute to encreaſe

* Derham's Phiſico Theol.

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the vernal and autumnal ſtorms, which are then known to prevail.

Upon narrowing the paſſage through which the air is driven, both the denſity and the ſwiftneſs of the wind is encreaſed. For as currents of water flow with greater force and rapidity by narrowing their channels, ſo alſo will a current of air, driven through a contracted ſpace, grow more violent and irreſiſtible. Hence we find thoſe dreadful ſtorms that prevail in the defiles of mountains, where the wind, puſhing from behind through a narrow channel, at once encreaſes in ſpeed and denſity, levelling, or tearing up, every obſtacle that riſes to obſtruct its paſſage.

Winds reflected from the ſides of mountains and towers, are often found to be more forceful than thoſe in direct progreſſion. This we frequently perceive near lofty buildings, ſuch as churches or ſteeples, where winds are generally known to prevail, and that much more powerful than at ſome diſtance. The air, in this caſe, by ſtriking againſt the ſide of the building, acquires additional denſity and, therefore, blows with more force.

Theſe differing degrees of denſity, which the air is found to poſſeſs, ſufficiently ſhew that the force of the winds do not depend

upon their velocity alone; ſo that thoſe inſtruments called *anemometers*, which are made to meaſure the velocity of the wind, will by no means give us certain information of the force of the ſtorm. In order to eſtimate this with exactneſs we ought to know its denſity; which alſo theſe are not calculated to diſcover. For this reaſon we often ſee ſtorms, with very powerful effects, that do not ſeem to ſhew any great ſpeed; and, on the contrary, we ſee theſe wind meaſurers go round, with great ſwiftneſs, when ſcarce any damage has followed from the ſtorm.

Such is the nature, and the inconſtancy, of the irregular winds with which we are beſt acquainted. But their effects are much more formidable in thoſe climates, near the tropics, where they are often found to break in upon the ſteady courſe of the trade-winds, and to mark their paſſage with deſtruction. With us the tempeſt is but rarely known, and its ravages are regiſtered as an uncommon calamity; but, in the countries that lie between the tropics, and for a good ſpace beyond them, its viſits are frequent, and its effects anticipated. In theſe regions the winds vary their terrors; ſometimes involving all things in a ſuffocating heat; ſometimes mixing all the elements of fire, air, earth, and water together; ſometimes, with a momen-

a momentary ſwiftneſs, paſſing over the face of the country, and deſtroying all things in their paſſage; and ſometimes raiſing whole ſandy deſerts in one country, to depoſit them upon ſome other. We have little reaſon, therefore, to envy theſe climates, the luxuriance of their ſoil, or the brightneſs of their ſkies. Our own muddy atmoſphere, that wraps us round in obſcurity, though it fails to gild our proſpects with ſun-ſhine, or our groves with fruitage, nevertheleſs anſwers the calls of induſtry. They may boaſt of a plentiful, but precarious harveſt; while, with us, the labourer toils in a certain expectation of a moderate, but an happy return.

In Egypt*, a kingdom ſo noted for its fertility, and the brightneſs of its atmoſphere, during ſummer, the ſouth winds are ſo hot, that they almoſt ſtop reſpiration; beſides which, they are charged with ſuch quantities of ſand, that they ſometimes darken the air, as with a thick cloud. Theſe ſands are ſo fine, and driven with ſuch violence, that they penetrate every where; even into cheſts, be they ſhut ever ſo cloſely. If theſe winds happen to continue for any length of time, they produce epidemic diſeaſes; and are often followed by a great mortality. It is alſo found to rain but very ſel-

* Buffon, vol. ii. p. 258.

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dom in that country; however, the want of ſhowers is richly compenſated by the copiouſneſs of their dews, which greatly tend to promote vegetation.

In Perſia, the winter begins in November, and continues till March. The cold at that time is intenſe enough to congeal the water; and ſnow falls, in abundance, upon their mountains. During the months of March and April, winds ariſe, that blow with great force, and ſeem to uſher in the heats of ſummer. Theſe return again, in autumn, with ſome violence; without, however, producing any dreadful effects. But, during their ſummer, all along the coaſts of the Perſian Gulph, a very dangerous wind prevails, which the natives call the Sameyel, ſtill more dreadful and burning than that of Egypt, and attended with inſtant and fatal effects. This terrible blaſt, which was, perhaps, the peſtilence of the ancients, inſtantly kills all thoſe that it involves in its paſſage. What its malignity conſiſts in, none can tell, as none have ever ſurvived its effects, to give information. It frequently, as I am told, aſſumes a viſible form; and darts, in a kind of bluiſh vapour, along the ſurface of the country. The natives, not only of Perſia, but Arabia, talk of its effects with terror; and their poets have not failed to heighten them, with the aſſiſtance of imagination.

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They have deſcribed it as under the conduct of a miniſter of vengeance, who governs its terrors, and raiſes, or depreſſes it, as he thinks proper *. Theſe deadly winds are alſo known along the coaſts of India, at Necapatan, Maſulipatan, and Petapoli. But, luckily for mankind, the ſhortneſs of their duration diminiſhes the injuries that might enſue from their malignity.

The Cape of Good Hope, as well as many iſlands in the Weſt-Indies, are famous for their hurricanes, and that extraordinary kind of cloud which is ſaid to produce them. This cloud, which is the fore-runner of an approaching hurricane, appears, when firſt ſeen, like a ſmall black ſpot, on the verge of the horizon; and is called, by ſailors, the bull's eye, from being ſeen ſo minute at a vaſt diſtance. All this time, a perfect calm reigns over the ſea and land, while the cloud grows gradually broader as it approaches. At length, coming to the place where its fury is to fall, it inveſts the whole horizon with darkneſs. During all the time of its approach, an hollow murmur is heard in the cavities of the mountains; and beaſts and animals, ſenſible of its approach, are ſeen running over the fields, to ſeek for ſhelter. Nothing can be more terrible than its violence when it begins. The houſes in thoſe

* Herbelot. Bibliotheque Oriental.

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countries, which are made of timber, the better to reſiſt its fury, bend to the blaſt like oſiers, and again recover their rectitude. The ſun, which, but a moment before, blazed with meridian ſplendor, is totally ſhut out; and a midnight darkneſs prevails, except that the air is inceſſantly illuminated with gleams of lightening, by which one can eaſily ſee to read. The rain falls, at the ſame time, in torrents; and its deſcent has been reſembled to what pours from the ſpouts of our houſes after a violent ſhower. Theſe hurricanes are not leſs offenſive to the ſenſe of ſmelling alſo; and never come without leaving the moſt noiſome ſtench behind them. If the ſeamen alſo lay by their wet cloaths, for twenty-four hours, they are all found ſwarming with little white maggots, that were brought with the hurricane. Our firſt mariners, when they viſited theſe regions, were ignorant of its effects, and the ſigns of its approach; their ſhips, therefore, were daſhed to the bottom at the firſt onſet; and numberleſs were the wrecks which the hurricane occaſioned. But, at preſent, being fore-warned of its approach, they ſtrip their maſts of all their ſails, and thus patiently abide its fury. Theſe hurricanes are common in all the tropical climates. On the coaſts of Guinea they have frequently three, or four, in a day, that thus

ſhut out the heavens, for a little ſpace; and when paſt leave all again in former ſplendor. They chiefly prevail, on that coaſt, in the intervals of the trade winds; the approach of which clears the air of its meteors, and gives theſe mortal ſhowers that little degree of wholeſomeneſs which they poſſeſs. They chiefly obtain there during the months of April and May; they are known, at Loango, from January to April; on the oppoſite coaſt of Africa, the hurricane ſeaſon begins in May; and, in general, whenever a trade wind begins to ceaſe, theſe irregular tempeſts are found to exert their fury.

All this is terrible; but there is a tempeſt, known to thoſe climates, more formidable than any we have hitherto been deſcribing, which is called, by the Spaniards, a Tornado. As the former was ſeen arriving from one part of the heavens, and making a line of deſtruction; ſo the winds in this ſeem to blow from every quarter, and ſettle upon one deſtined place, with ſuch fury, that nothing can reſiſt their vehemence. When they have all met, in their central ſpot, then the whirlwind begins with circular rapidity. The ſphere, every moment widens, as it continues to turn, and catches every object that lies within its attraction. This, alſo, like the former, is preceded by a flattering calm; the air is every where huſhed; and the ſea is as ſmooth as

poliſhed

poliſhed glaſs: however, as its effects are more dreadful than thoſe of the ordinary hurricane, the mariner tries all the power of his ſkill to avoid it; which, if he fails of doing, there is the greateſt danger of his going to the bottom. All along the coaſts of Guinea, beginning about two degrees north of the line, and ſo downward, lengthwiſe, for about a thouſand miles, and as many broad, the ocean is unnavigable, upon account of theſe tornados. In this torpid region there reign unceaſing tornados, or continual calms; among which, whatever ſhip is ſo unhappy as to fall, is totally deprived of all power of eſcaping. In this dreadful repoſe of all the elements, the ſolitary veſſel is obliged to continue, without a ſingle breeze to aſſiſt the mariner's wiſhes, except thoſe whirlwinds, which only ſerve to encreaſe his calamity. At preſent, therefore, this part of the ocean is totally avoided; and, although there may be much gold along the coaſts of that part of Africa, to tempt avarice, yet there is ſomething, much more dreadful than the fabled dragon of antiquity, to guard the treaſure. As the internal parts of that country are totally unknown to travellers, from their burning ſands and extenſive deſarts, ſo here we find a vaſt tract of ocean, lying off its ſhores, equally unviſited by the mariner.

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But of all thoſe terrible tempeſts that deform the face of nature, and repreſs human preſumption, the ſandy tempeſts of Arabia and Africa, are the moſt terrible, and ſtrike the imagination moſt ſtrongly. To conceive a proper idea of theſe, we are by no means to ſuppoſe them reſembling thoſe whirlwinds of duſt that we ſometimes ſee ſcattering in our air, and ſprinkling their contents upon our roads, or meadows. The ſand-ſtorm of Africa, exhibits a very different appearance. As the ſand of which the whirlwind is compoſed, is exceſſively fine, and almoſt reſembles the parts of water, its motion entirely reſembles that of a fluid; and the whole plain ſeems to float onward, like a ſlow inundation. The body of ſand thus rolling, is deep enough to bury houſes and palaces in its boſom: travellers who are croſſing thoſe extenſive deſerts, perceive its approach at a diſtance; and, in general, have time to avoid it, or turn out of its way, as it generally extends but to a moderate breadth. However, when it is extremely rapid, or very extenſive, as ſometimes is the caſe, no ſwiftneſs, no art, can avail; nothing then remains, but to meet death with fortitude, and ſubmit to be buried alive with reſignation.

It is happy for us of Britain, that we have no ſuch calamity to fear; for, from this, even ſome parts of Europe are not entirely free. We have an account given us, in the Hiſtory of the French Academy, of a miſerable town of France, that is conſtantly in danger of being buried under a ſimilar inundation; with which I will take leave to cloſe this chapter. "In the neighbourhood of St. Paul de Leon, in Lower Brittany *, there lies a tract of country along the ſea-ſide, which before the year 1666 was inhabited, but now lies deſerted, by reaſon of the ſands which cover it, to the height of twenty feet; and which every year advance more and more in land, and gain ground continually. From the time mentioned above, the ſand has buried more than ſix leagues of the country inward; and it is now but half a league from the town of St. Paul; ſo that, in all appearance, the inhabitants muſt be obliged to abandon it entirely. In the country that has been overwhelmed, there are ſtill to be ſeen the tops of ſome ſteeples peeping through the ſand, and many chimnies that ſtill remain above this ſandy ocean. The inhabitants, however, had ſufficient time to eſcape; but being deprived of their little all, they had no other

* Hiſtoire de l'Accademie des Sciences, an. 1722.

reſource

reſource but begging for their ſubſiſtence. This calamity chiefly owes its advancement to a north, or an eaſt wind, raiſing the ſand, which is extremely fine, in ſuch great quantities, and with ſuch velocity, that M. Deſlands, who gave the account, ſays, that while he was walking near the place, during a moderate breeze of wind, he was obliged, from time to time, to ſhake the ſand from his cloaths and his hat, on which it was lodged in great quantities, and made them too heavy to be eaſily borne. Still further, when the wind was violent, it drove the ſand acroſs a little arm of the ſea, into the town of Roſcoff, and covered the ſtreets of that place two feet deep; ſo that they have been obliged to carry it off in carts. It may alſo be obſerved, that there are ſeveral particles of iron mixed with the ſand, which are readily affected by the loadſtone. The part of the coaſt that furniſhes theſe ſands, is a tract of about four leagues in length; and is upon a level with the ſea at high water. The ſhore lies in ſuch a manner as to leave its ſands ſubject only to the north and eaſt winds, that bear them farther up the ſhore. It is eaſy to conceive how the ſame ſand that has at one time been borne a ſhort way in land, may, by ſome ſucceeding and ſtronger blaſt,

blaſt, be carried up much higher; and thus the whole may continue advancing forward, deluging the plain, and totally deſtroying its fertility. At the ſame time, the ſea, from whence this deluge of ſand proceeds may furniſh it in inexhauſtible quantities. This unhappy country, thus overwhelmed in ſo ſingular a manner, may well juſtify what the ancients and the moderns have reported concerning thoſe tempeſts of ſand in Africa, that are ſaid to deſtroy villages, and even armies, in their boſom."

CHAP. XXI.

Of Meteors, and ſuch Appearances as reſult from a Combination of the Elements.

IN proportion as the ſubſtances of nature are more compounded and combined, their appearances become more inexplicable and amazing. The properties of water have been very nearly aſcertained. Many of the qualities of air, earth, and fire, have been diſcovered, and eſtimated; but when theſe come to be united by Nature, they often produce a reſult which no artificial combinations can imitate; and we ſtand ſurprized, that although we are poſſeſſed of all thoſe ſubſtances which Nature makes uſe of, ſhe ſhews herſelf a much more various operator than the moſt ſkilful chymiſt ever appeared to be. Every cloud that moves, and every ſhower that falls, ſerves to mortify the philoſopher's pride, and to ſhew him hidden qualities in air and water, that he finds it difficult to explain. Dews, hail, ſnow, and thunder, are not leſs difficult for being more common. Indeed, when we reflect on the manner in which Nature performs any one of theſe operations, our wonder encreaſes. To ſee water, which is heavier than air, riſing in air, and then

then falling in a form ſo very different from that in which it roſe; to ſee the ſame fluid at one time deſcending in the form of hail, at another in that of ſnow; to ſee two clouds, by daſhing againſt each other, producing an electrical fire, which no watery compoſition that we know of can effect; theſe, I ſay, ſerve ſufficiently to excite our wonder; and ſtill the more, in proportion as the objects are ever preſſing on our curioſity. Much, however, has been written concerning the manner in which Nature operates in theſe productions; as nothing is ſo ungrateful to mankind as hopeleſs ignorance.

And firſt, with regard to the manner in which water evaporates, and riſes to form clouds, much has been advanced, and many theories deviſed. All water *, ſay ſome, has a quantity of air mixed with it; and the heat of the ſun darting down, diſengages the particles of this air from the groſſer fluid: the ſun's rays being reflected back from the water, carry back with them thoſe bubbles of air and water which, being lighter than the condenſed air, will aſcend till they meet with more rareſied air; and they will then ſtand ſuſpended. Experience, however, proves nothing of all this. Particles of air or fire, are not thus known to aſcend with a thin coat of water; and, in fact, we know that the lit-

* Spectacle de la Nature, vol. iii.

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tle particles of ſteam are ſolid drops of water. But beſides this, water is known to evaporate more powerfully in the ſevereſt froſt, than when the air is moderately warm *. Doctor Hamilton, therefore, of the univerſity of Dublin, rejecting this theory, has endeavoured to eſtabliſh another. According to him, as aqua fortis is a menſtruum that diſſolves iron, and keeps it mixed in the fluid; as aqua regia is a menſtruum that diſſolves gold; or as water diſſolves ſalts to a certain quantity; ſo air is a menſtruum that corrodes and diſſolves a certain quantity of water, and keeps it ſuſpended above. But however ingenious this may be, it can hardly be admitted; as we know, by Mariotte's experiment †, that if water and air be encloſed together, inſtead of the air's acting as a menſtruum upon the water, the water will act as a menſtruum upon the air, and take it all up. We know alſo, that of two bodies, that which is moſt fluid and penetrating, is moſt likely to be the menſtruum of the other; but water is more fluid and penetrating than air, and, therefore, the moſt likely of the two to be the menſtruum. We know that all bodies are more ſpeedily acted upon, the more their parts are brought

* Memoires de l'Accademie des Sciences, an. 1705.

† Mariottoe, de la Nature de l'Air, p. 97, 106.

into contact with the menſtruum that diſſolves them: but water, incloſed with compreſt air, is not the more diminiſhed thereby *. In ſhort, we know, that cold, which diminiſhes the force of other menſtruums, is often found to promote evaporation. In this variety of opinion, and uncertainty of conjecture, I cannot avoid thinking that a theory of evaporation may be formed upon very ſimple and obvious principles, and embarraſſed, as far as I can conceive, with very few objections.

We know that a repelling power prevails in nature, not leſs than an attractive one. This repulſion prevails ſtrongly between the body of fire and that of water. If I plunge the end of a red hot bar of iron into a veſſel of water, the fluid riſes, and large drops of it fly up in all manner of directions, every part bubbling and ſteaming until the iron be cold. Why may we not, for a moment, compare the rays of the ſun, darted directly upon the ſurface of the water, to ſo many bars of red hot iron; each bar, indeed, infinitely ſmall, but not the leſs powerful? In this caſe, wherever a ray of fire darts, the water, from its repulſive quality, will be driven on all ſides; and, of conſequence, as in the caſe of the bar of iron, a part of it will riſe. The

* See Boyle's Works, vol. ii. p. 619.

parts

parts thus riſing, however, will be extremely ſmall; as the ray that darts is extremely ſo. The aſſemblage of the rays darting upon the water in this manner, will cauſe it to riſe in a light thin ſteam above the ſurface; and as the parts of this ſteam are extremely minute, they will be lighter than air, and, conſequently, float upon it. There is no need for ſuppoſing them bubbles of water, filled with fire; for any ſubſtance, even gold itſelf, will float on air, if its parts be made ſmall enough; or, in other words, if its ſurface be ſufficiently encreaſed. This water, thus diſengaged from the general maſs, will be ſtill farther attenuated and broken by the reflected rays, and, conſequently, more adapted for aſcending.

From this plain account, every appearance in evaporation may be eaſily deduced. The quantity of heat encreaſes evaporation, becauſe it raiſes a greater quantity of ſteam. The quantity of wind encreaſes evaporation; for, by waving the ſurface of the water, it thus expoſes a greater ſurface to the evaporating rays. A dry froſt, in ſome meaſure aſſiſts the quantity of evaporation; as the quantity of rays are found to be no way diminiſhed thereby. Moiſt weather alone prevents evaporation; for the rays being abſorbed, refracted, and broken, by the

intervening moiſture, before they arrive at the ſurface, cannot produce the effect; and the vapour will riſe in a ſmall proportion.

Thus far we have accounted for the aſcent of vapours; but to account for their falling again, is attended with rather more difficulty. We have already obſerved, that the particles of vapour, diſengaged from the ſurface of the water, will be broken and attenuated in their aſcent, by the reflected, and even the direct rays, that happen to ſtrike upon their minute ſurfaces. They will, therefore, continue to aſcend, till they riſe above the operation of the reflected rays, which reaches but to a certain height above the ſurface of the earth. Being arrived at this region, which is cold for want of reflected heat, they will be condenſed, and ſuſpended in the form of clouds. Some vapours that aſcend to great heights, will be frozen into ſnow; others, that are condenſed lower down, will put on the appearance of a miſt, which we find the clouds to be, when we aſcend among them, as they hang along the ſides of a mountain. Theſe clouds of ſnow and rain, being blown about by winds, are either entirely ſcattered and diſperſed above, or they are ſtill more condenſed by motion, like a ſnow-ball, that grows more large and ſolid as it continues to roll. At laſt, therefore, they will become

become too weighty for the air which firſt raiſed them, to ſuſtain: and they will deſcend, with their exceſs of weight, either in ſnow or rain. But as they will fall precipitately, when they begin to deſcend, the air, in ſome meaſure, will reſiſt the falling; for, as the deſcending fluid gathers velocity in its precipitation, the air will encreaſe its reſiſtance to it, and the water will, therefore, be thus broken into rain; as we ſee, that water which falls from the tops of houſes, though it begins in a ſpout, ſeparates into drops before it has got to the bottom. Were it not for this happy interpoſition of the air between us and the water falling from a conſiderable height above us, a drop of rain might fall with dangerous force, and an hail-ſtone might ſtrike us with fatal rapidity.

In this manner, evaporation is produced by day; but when the ſun goes down, a part of that vapour which his rays had excited, being no longer broken, and attenuated by the reflecting rays, it will become heavier than the air, even before it has reached the clouds; and it will, therefore, fall back in dews, which differ only from rain in deſcending before they have had time to condenſe into a viſible form.

Hail, the Carteſians ſay, is a frozen cloud, half

half melted, and frozen again in its deſcent. An hoar-froſt is but a frozen dew. Lightening we know to be an electrical flaſh, produced by the oppoſition of two clouds: and thunder to be the ſound proceeding from the ſame, continued by an echo reverberated among them. It would be to very little purpoſe, to attempt explaining exactly how theſe wonders are effected: we have as yet but little inſight into the manner in which theſe meteors are found to operate upon each other; and, therefore, we muſt be contented with a detail rather of their effects than their cauſes.

In our own gentle climate, where Nature wears the mildeſt and kindeſt aſpect, every meteor ſeems to befriend us. With us, rains fall in refreſhing ſhowers, to enliven our fields, and to paint the landſcape with a more vivid beauty. Snows cover the earth, to preſerve its tender vegetables from the inclemency of the departing winter. The dews deſcend with ſuch an imperceptible fall as no way injures the conſtitution. Thunder itſelf is ſeldom injurious; and it is often wiſhed by the huſbandman, to clear the air, and to kill numberleſs inſects that are noxious to vegetation. Hail is the moſt injurious meteor that is known in our climate; but it ſeldom viſits us with violence, and then its fury is but tranſient.

One

One of the moſt dreadful ſtorms we hear of *, was that at Hertfordſhire, in the year 1697. It began by thunder and lightening, which continued for ſome hours, when ſuddenly a black cloud came forward, againſt the wind, and marked its paſſage with devaſtation. The hail-ſtones which it poured down, being meaſured, were found to be many of them fourteen inches round, and, conſequently, as large as a bowling-green ball. Wherever it came, every plantation fell before it; it tore up the ground, ſplit great oaks, and other trees, without number; the fields of rye were cut down, as if levelled with a ſcythe; wheat, oats, and barley, ſuffered the ſame damage. The inhabitants found but a precarious ſhelter, even in their houſes, their tiles and windows being broke by the violence of the hail-ſtones, which, by the force with which they came, ſeemed to have deſcended from a great height. The birds, in this univerſal wreck, vainly tried to eſcape by flight; pigeons, crows, rooks, and much more of the ſmaller and feebler kinds, were brought down. An unhappy young man, who had not time to take ſhelter, was killed; one of his eyes was ſtruck out of his head, and his body was all over black with the bruiſes: another had juſt time to eſcape, but not with-

* Phil. Tranſ. vol. ii. p. 147.

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out the moſt imminent danger, his body being bruiſed all over. But what is moſt extraordinary, all this fell within the compaſs of a mile.

Mezeray, in his Hiſtory of France, tells us of a ſhower of hail much more terrible, which happened in the year 1510, when the French monarch invaded Italy. There was, for a time, an horrid darkneſs, thicker than that of midnight, which continued till the terrors of mankind were changed to ſtill more terrible objects, by thunder and lightening breaking the gloom, and bringing on ſuch a ſhower of hail, as no hiſtory of human calamities could equal. Theſe hail-ſtones were of a bluiſh colour; and ſome of them weighed not leſs than an hundred pounds. A noiſome vapour of ſulphur attended the ſtorm. All the birds and beaſts of the country were entirely deſtroyed. Numbers of the human race ſuffered the ſame fate. But what is ſtill more extraordinary, the fiſhes themſelves found no protection from their native element; but were equal ſufferers in the general calamity.

Theſe, however, are terrors that are ſeldom exerted in our mild climates. They only ſerve to mark the page of hiſtory with wonder; and ſtand as admonitions to mankind, of the various ſtores of puniſhment in the hands of

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the Deity, which his power can treaſure up, and his mercy can ſuſpend.

In the temperate zone, therefore, meteors are rarely found thus terrible; but between the tropics, and near the poles, they aſſume very dreadful and various appearances. In thoſe inclement regions, where cold and heat exert their chief power, meteors ſeem peculiarly to have fixed their reſidence. They are ſeen there in a thouſand terrifying forms, aſtoniſhing to Europeans, yet diſregarded by the natives, from their frequency. The wonders of air, fire, and water, are there combined, to produce the moſt tremendous effects; and to ſport with the labours and apprehenſions of mankind. Lightenings, that flaſh without noiſe; hurricanes, that tear up the earth; clouds, that all at once pour down their contents, and produce an inſtant deluge; mock ſuns; northern lights, that illuminate half the hemiſphere; circular rainbows; halo's; fleeting balls of fire; clouds, reflecting back the images of things on earth, like mirrors; and water-ſpouts, that burſt from the ſea, to join with the miſts that hang immediately above them. Theſe are but a part of the phænomena that are common in thoſe countries; and from many of which, our own climate is, in a great meaſure, exempted.

The

The meteors of the torrid zone, however, are different from thoſe that are found near the polar circles: and it may readily be ſuppoſed, that in thoſe countries where the ſun exerts the greateſt force in raiſing vapours of all kinds, there ſhould be the greateſt quantity of meteors. Upon the approach of the winter months, as they are called, under the line, which uſually begin about May, the ſky, from a fiery brightneſs, begins to be overcaſt, and the whole horizon ſeems wrapt in a muddy cloud. Miſts and vapours ſtill continue to riſe; and the air, which ſo lately before was clear and elaſtic, now becomes humid, obſcure, and ſtifling: the fogs become ſo thick, that the light of the ſun ſeems in a manner excluded; nor would its preſence be known, but for the intenſe and ſuffocating heat of its beams, which dart through the gloom, and, inſtead of diſſipating, only ſerve to encreaſe the miſt. After this preparation, there follows an almoſt continual ſucceſſion of thunder, rain, and tempeſts. During this dreadful ſeaſon, the ſtreets of cities flow like rivers; and the whole country wears the appearance of an ocean. The inhabitants often make uſe of this opportunity to lay in a ſtock of freſh water, for the reſt of the year; as the ſame cauſe which pours down

down the deluge at one ſeaſon, denies the kindly ſhower at another. The thunder which attends the fall of theſe rains, is much more terrible than that we are generally acquainted with. With us, the flaſh is ſeen at ſome diſtance, and the noiſe ſhortly after enſues; our thunder generally rolls on one quarter of the ſky, and one ſtroke purſues another. But here it is otherwiſe; the whole ſky, all around, ſeems illuminated with unremitted flaſhes of lightening; every part of the air ſeems productive of its own thunders; and every cloud produces its own ſhock. The ſtrokes come ſo thick, that the inhabitants can ſcarce mark the intervals; but all is one unremitted roar of elementary confuſion. It ſhould ſeem, however, that the lightening of thoſe countries is not ſo fatal, or ſo dangerous, as with us; ſince, in this caſe, the torrid zone would be uninhabitable.

When theſe terrors have ceaſed, with which, however, the natives are familiar, meteors of another kind begin to make their appearance. The intenſe beams of the ſun, darting upon ſtagnant waters, that generally cover the ſurface of the country, raiſe vapours of various kinds. Floating bodies of fire, which aſſume different names, rather from their accidental forms, than from any real

real difference between them, are ſeen without ſurprize. The draco volans, or flying dragon, as it is called; the ignis fatuus, or wandering fire; the fires of St. Helmo, or the mariner's light, are every where frequent; and of theſe we have numberleſs deſcriptions. "As I was riding in Jamaica," ſays Mr. Barbham, "one morning from my habitation, ſituated about three miles northweſt from Jago de la Bega, I ſaw a ball of fire, appearing to me of the bigneſs of a bomb, ſwiftly falling down with a great blaze. At firſt I thought it fell into the town; but when I came nearer, I ſaw many people gathered together, a little to the ſouthward, in the Savannah, to whom I rode up, to enquire the cauſe of their meeting: they were admiring, as I found, the ground's being ſtrangely broke up and ploughed by a ball of fire; which, as they ſaid, fell down there. I obſerved there were many holes in the ground; one in the middle of the bigneſs of a man's head, and five or ſix ſmaller round about it, of the bigneſs of one's fiſt, and ſo deep as not to be fathomed by ſuch implements as were at hand. It was obſerved, alſo, that all the green herbage was burnt up, near the holes; and there continued a ſtrong ſmell of ſulphur near the place, for ſome time after."

Ulloa gives an account of one of a ſimilar kind, at Quito*. "About nine at night," ſays he, "a globe of fire appeared to riſe from the ſide of the mountain Pichinca, and ſo large, that it ſpread a light over all the part of the city facing that mountain. The houſe where I lodged, looking that way, I was ſurprized with an extraordinary light, darting through the crevices of the window-ſhutters. On this appearance, and the buſtle of the people, in the ſtreet, I haſtened to the window, and came time enough to ſee it, in the middle of its career; which continued from weſt to ſouth, till I loſt ſight of it, being intercepted by a mountain, that lay between me and it. It was round; and its apparent diameter about a foot. I obſerved it to riſe from the ſides of Pichinca; although, to judge from its courſe, it was behind that mountain where this congeries of inflammable matter was kindled. In the firſt half of its viſible courſe it emitted a prodigious effulgence, then it began gradually to grow dim; ſo that, upon its diſappearing behind the intervening mountain, its light was very faint."

Meteors, of this kind, are very frequently ſeen between the tropics; but they ſometimes, alſo, viſit the more temperate regions

* Ulloa, vol. i. p. 41.

of

of Europe. We have the deſcription of a very extraordinary one, given us by Montanari, that ſerves to ſhew to what great heights, in our atmoſphere, theſe vapours are found to aſcend. In the year 1676, a great globe of fire was ſeen at Bononia, in Italy, about three quarters of an hour after ſun-ſet. It paſt weſtward, with a moſt rapid courſe, and at the rate of not leſs than a hundred and ſixty miles in a minute, which is much ſwifter than the force of a cannon-ball, and, at laſt, ſtood over the Adriatic ſea. In its courſe it croſſed over all Italy; and, by computation, it could not have been leſs than thirty-eight miles above the ſurface of the earth. In the whole line of its courſe, wherever it approached, the inhabitants below could diſtinctly hear it, with a hiſſing noiſe, reſembling that of a fire-work. Having paſt away to ſea, towards Corſica, it was heard, at laſt, to go off with a moſt violent exploſion, much louder than that of a cannon; and, immediately after, another noiſe was heard, like the rattling of a great cart, upon a ſtony pavement; which was, probably, nothing more than the echo of the former ſound. Its magnitude, when at Bononia, appeared twice as long as the moon, one way; and as broad the other; ſo that, conſidering its height, it could not have been leſs than a mile long, and half a mile broad.

broad. From the height at which this was ſeen, and there being no volcano, on that quarter of the world, from whence it came, it is more than probable that this terrible globe was kindled on ſome part of the contrary ſide of the globe, in thoſe regions of vapours, which we have been juſt deſcribing; and thus, riſing above the air, and paſſing, in a courſe oppoſite to that of the earth's motion, in this manner it acquired its amazing rapidity.

To theſe meteors, common enough ſouthward, we will add one more of a very uncommon kind, which was ſeen, by Ulloa, at Quito, in Peru: the beauty of which will, in ſome meaſure, ſerve to relieve us, after the deſcription of thoſe hideous ones preceding. "At day-break," ſays he, "the whole mountain of Pambamarca, where we then reſided, was encompaſſed with very thick clouds; which the riſing of the ſun diſperſed ſo far, as to leave only ſome vapours, too fine to be ſeen. On the ſide oppoſite to the riſing ſun, and about ten fathoms diſtant from the place where we were ſtanding, we ſaw, as in a looking-glaſs, each his own image; the head being, as it were, the centre of three circular rainbows, one without the other, and juſt near enough to each other as that the colours of the internal verged upon thoſe more external; while round

round all was a circle of white, but with a greater ſpace between. In this manner theſe circles were erected, like a mirror, before us; and as we moved, they moved, in diſpoſition and order. But, what is moſt remarkable, though we were ſix in number, every one ſaw the phænomenon, with regard to himſelf, and not that relating to others. The diameter of the arches gradually altered, as the ſun roſe above the horizon; and the whole, after continuing a long time, inſenſibly faded away. In the beginning, the diameter of the inward iris, taken from its laſt colour, was about five degrees and a half; and that of the white arch, which ſurrounded the reſt, was not leſs than ſixty-ſeven degrees. At the beginning of the phænomenon, the arches ſeemed of an oval or eliptical figure, like the diſk of the ſun; and afterwards became perfectly circular. Each of theſe was of a red colour, bordered with an orange; and the laſt bordered by a bright yellow, which altered into a ſtraw colour, and this turned to a green; but, in all, the external colour remained red." Such is the deſcription of one of the moſt beautiful illuſions that has been ever ſeen in nature. This alone ſeems to have combined all the ſplendors of optics in one view. To underſtand the manner, therefore, how this phænomenon was produced,

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would require a perfect knowledge of optics; which it is not our preſent province to enter upon. It will be ſufficient here, therefore, only to obſerve, that all theſe appearances ariſe from the denſity of the cloud, together with its uncommon and peculiar ſituation, with reſpect to the ſpectator and the ſun. It may be obſerved, that but one of theſe three rain-bows was real, the reſt being only reflections thereof. It may alſo be obſerved, that whenever the ſpectator ſtands between the ſun and a cloud of falling rain, a rainbow is ſeen, which is nothing more than the reflection of the different coloured rays of light from the boſom of the cloud. If, for inſtance, we take a glaſs globe, filled with water, and hang it up before us, oppoſite the ſun, in many ſituations, it will appear tranſparent; but if it is raiſed higher, or ſideways, to an angle of forty-five degrees, it will at firſt appear red; altered a very little higher, yellow; then green, then blue, then violet colour: in ſhort, it will aſſume ſucceſſively all the colours of the rainbow; but, if raiſed higher, ſtill it will become tranſparent again. A falling ſhower may be conſidered as an infinite number of theſe little tranſparent globes, aſſuming different colours, by being placed at the proper heights. The reſt of the ſhower will appear

tranſparent, and no part of it will ſeem coloured; but ſuch as are at angles of forty-five degrees from the eye, forty-five degrees upward, forty-five degrees on each ſide, and forty-five degrees downward, did not the plain of the earth prevent us. We, therefore, ſee only an arch of the rainbow, the lower part being cut off from our ſight by the earth's interpoſition. However, upon the tops of very high mountains, circular rainbows are ſeen, becauſe we can ſee to an angle of forty-five degrees downward, as well as upward, or ſideways, and therefore we take in the rainbow's complete circle.

In thoſe forlorn regions, round the poles, the meteors, though of another kind, are not leſs numerous and alarming. When the winter begins, and the cold prepares to ſet in, the ſame miſty appearance which is produced in the ſouthern climates by the heat, is there produced by the contrary extreme *. The ſea ſmokes like an oven, and a fog ariſes, which mariners call the froſt ſmoke. This cutting miſt moſt commonly raiſes bliſters on ſeveral parts of the body; and, as ſoon as it is wafted to ſome colder part of the atmoſphere, it freezes to little icy particles, which are driven by the wind, and create ſuch a cutting cold on land, that

* Paul Egede's Hiſtory of Greenland.

the limbs of the inhabitants are ſometimes frozen, and drop off.

There alſo, halos, or luminous circles round the moon, are oftener ſeen than in any other part of the earth, being formed by the froſt ſmoke; although the air otherwiſe ſeems to be clear. A lunar rainbow alſo, is often ſeen there, though ſomewhat different from that which is common with us; as it appears of a pale white, ſtriped with grey. In theſe countries alſo, the aurora borealis ſtreams, with peculiar luſtre, and variety of colours. In Greenland it generally ariſes in the eaſt, and darts its ſportive fires, with variegated beauty, over the whole horizon. Its appearance is almoſt conſtant in winter; and, at thoſe ſeaſons when the ſun departs, to return no more for half a year, this meteor kindly riſes to ſupply its beams, and affords ſufficient light for all the purpoſes of exiſtence. However, in the very midſt of their tedious night, the inhabitants are not entirely forſaken. The tops of the mountains are often ſeen painted with the red rays of the ſun; and the poor Greenlander from thence begins to date his chronology. It would appear whimſical to read a Greenland calendar, in which we might be told, that one of their chiefs, having lived forty days, died, at laſt, of a good old age; and

that his widow continued for half a day, to deplore his loſs, with great fidelity, before ſhe admitted a ſecond huſband.

The meteors of the day, in theſe countries, are not leſs extraordinary than thoſe of the night: mock ſuns are often reflected upon an oppoſite cloud; and the ignorant ſpectator fancies that there are often three or four real ſuns in the firmament at the ſame time. In this ſplendid appearance the real ſun is always readily known by its ſuperior brightneſs, every reflexion being ſeen with diminiſhed ſplendor. The ſolar rainbow there is often ſeen different from ours. Inſtead of a pleaſing variety of colours, it appears of a pale white, edged with a ſtripe of duſky yellow; the whole being reflected from the boſom of a frozen cloud.

But, of all the meteors which mock the imagination with an appearance of reality, thoſe ſtrange illuſions that are ſeen there, in fine ſerene weather, are the moſt extraordinary and entertaining. "Nothing," ſays Krantz, "ever ſurprized me more, than, on a fine warm ſummer's day, to perceive the iſlands that lie four leagues weſt of our ſhore, putting on a form quite different from what they are known to have. As I ſtood gazing upon them, they appeared, at firſt, infinitely greater than what they naturally are; and

ſeemed

ſeemed as if I viewed them through a large magnifying glaſs. They were not thus only made larger, but brought nearer to me. I plainly deſcried every ſtone upon the land, and all the furrows filled with ice, as if I ſtood cloſe by. When this illuſion had laſted for a while, the proſpect ſeemed to break up, and a new ſcene of wonder to preſent itſelf. The iſlands ſeemed to travel to the ſhore, and repreſented a wood, or a tall cut hedge. The ſcene then ſhifted, and ſhewed the appearance of all ſorts of curious figures; as ſhips with ſails, ſtreamers, and flags; antique elevated caſtles, with decayed turrets; and a thouſand forms, for which fancy found a reſemblance in nature. When the eye had been ſatisfied with gazing, the whole groupe of riches ſeemed to riſe in air, and at length vaniſh into nothing. At ſuch times the weather is quite ſerene and clear; but compreſt with ſuch ſubtle vapours, as it is in very hot weather; and theſe appearing between the eye and the object, give it all that variety of appearances which glaſſes of different refrangibilities would have done." Mr. Krantz obſerves that, commonly a couple of hours afterwards, a gentle weſt wind and a viſible miſt follow, which put an end to this *luſus naturæ*.

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It were eaſy to ſwell this catalogue of meteors with the names of many others, both in our own climate and in other parts of the world. Such as falling ſtars, which are thought to be no more than unctuous vapours, raiſed from the earth to ſmall heights, and continuing to ſhine till that matter which firſt raiſed, and ſupported them, being burnt out, they fall back again to the earth, with extinguiſhed flame. Burning ſpears, which are a peculiar kind of aurora borealis; bloody rains which are ſaid to be the excrements of an inſect, that at that time has been raiſed into the air. Showers of ſtones, fiſhes, and ivy-berries, at firſt, no doubt, raiſed into the air by tempeſts, in one country, and falling at ſome conſiderable diſtance, in the manner of rain, to aſtoniſh another. But omitting theſe, of which we know little more than what is thus briefly mentioned, I will conclude this chapter with the deſcription of a water-ſpout; a moſt ſurprizing phænomenon; not leſs dreadful to mariners than aſtoniſhing to the obſerver of nature.

Theſe ſpouts are ſeen very commonly in the tropical ſeas, and ſometimes in our own. Thoſe ſeen by Tournefort, in the Mediterranean, he has deſcribed as follows. "The firſt of theſe," ſays this great botaniſt, "that we ſaw, was about a muſket-ſhot from our ſhip.

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There we perceived the water began to boil, and to riſe about a foot above its level. The water was agitated and whitiſh; and above its ſurface there ſeemed to ſtand a ſmoke, ſuch as might be imagined to come from wet ſtraw before it begins to blaze. It made a ſort of a murmuring ſound, like that of a torrent, heard at a diſtance, mixed, at the ſame time, with an hiſſing noiſe, like that of a ſerpent: ſhortly after we perceived a column of this ſmoke riſe up to the clouds, at the ſame time whirling about with great rapidity. It appeared to be as thick as one's finger; and the former ſound ſtill continued. When this diſappeared, after laſting for about eight minutes, upon turning to the oppoſite quarter of the ſky, we perceived another, which began in the manner of the former; preſently after a third appeared in the weſt; and inſtantly beſide it ſtill another aroſe. The moſt diſtant of theſe three could not be above a muſket ſhot from the ſhip. They all continued like ſo many heaps of wet ſtraw ſet on fire, that continued to ſmoke, and to make the ſame noiſe as before. We ſoon after perceived each, with its reſpective canal, mounting up in the clouds, and ſpreading where it touched; the cloud, like the mouth of a trumpet, making a figure, to expreſs it intelligibly,

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as if the tail of an animal were pulled at one end by a weight. Theſe canals were of a whitiſh colour, and ſo tinged, as I ſuppoſe, by the water which was contained in them; for previous to this, they were apparently empty, and of the colour of tranſparent glaſs. Theſe canals were not ſtraight, but bent in ſome parts, and far from being perpendicular, but riſing in their clouds with a very inclined aſcent. But what is very particular, the cloud to which one of them was pointed happening to be driven by the wind, the ſpout ſtill continued to follow its motion, without being broken; and paſſing behind one of the others, the ſpouts croſſed each other, in the form of a St. Andrew's croſs. In the beginning they were all about as thick as one's finger, except at the top, where they were broader, and two of them diſappeared; but ſhortly after, the laſt of the three encreaſed conſiderably; and its canal, which was at firſt ſo ſmall, ſoon became as thick as a man's arm, then as his leg, and at laſt thicker than his whole body. We ſaw diſtinctly, through this tranſparent body, the water, which roſe up with a kind of ſpiral motion; and it ſometimes diminiſhed a little of its thickneſs, and again reſumed the ſame; ſometimes widening at top, and ſometimes

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at bottom; exactly reſembling a gut filled with water, preſſed with the fingers, to make the fluid riſe, or fall; and I am well convinced, that this alteration in the ſpout was cauſed by the wind, which preſſed the cloud, and impelled it to give up its contents. After ſome time its bulk was ſo diminiſhed as to be no thicker than a man's arm again; and thus, ſwelling and diminiſhing, it at laſt became very ſmall. In the end, I obſerved the ſea which was raiſed about it to reſume its level by degrees, and the end of the canal that touched it to become as ſmall as if it had been tied round with a cord; and this continued till the light, ſtriking through the cloud, took away the view. I ſtill, however, continued to look, expecting that its parts would join again, as I had before ſeen in one of the others, in which the ſpout was more than once broken, and yet again came together; but I was diſappointed, for the ſpout appeared no more."

Many have been the ſolutions offered for this ſurprizing appearance. Mr. Buffon ſuppoſes the ſpout, here deſcribed, to proceed from the operation of fire, beneath the bed of the ſea; as the waters at the ſurface are thus ſeen agitated. However, the ſolution of Dr. Stuart is not diveſted of probability; who thinks it may be accounted for by ſuction,

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as in the application of a cupping-glaſs to the ſkin.

Wherever ſpouts of this kind are ſeen they are extremely dreaded by mariners; for if they happen to fall upon a ſhip they moſt commonly daſh it to the bottom. But, if the ſhip be large enough to ſuſtain the deluge, they are at leaſt ſure to deſtroy its ſails and rigging, and render it unfit for ſailing. It is ſaid that veſſels of any force uſually fire their guns at them, loaden with a bar of iron; and, if ſo happy as to ſtrike them, the water is inſtantly ſeen to fall from them, with a dreadful noiſe, though without any further miſchief.

I am at a loſs whether we ought to reckon thoſe ſpouts called typhons, which are ſometimes ſeen at land, of the ſame kind with thoſe ſo often deſcribed by mariners at ſea, as they ſeem to differ in ſeveral reſpects. That, for inſtance, obſerved at Hatfield, in Yorkſhire, in 1687, as it is deſcribed by the perſon who ſaw it, ſeems rather to have been a whirlwind than a water-ſpout. The ſeaſon in which it appeared was very dry, the weather extremely hot, and the air very cloudy. After the wind had blown for ſome time, with conſiderable force, and condenſed the black clouds one upon another, a great whirling

ling of the air enſued; upon which the center of the clouds, every now and then, darted down, in the ſhape of a thick long black pipe; in which the relator could diſtinctly view a motion, like that of a ſcrew, continually ſcrewing up to itſelf, as it were, whatever it happened to touch. In its progreſs it moved ſlowly over a grove of young trees, which it violently bent, in a circular motion. Going forward to a barn, it in a minute ſtript it of all the thatch, and filled the whole air with the ſame. As it came near the relator, he perceived that its blackneſs proceeded from a gyration of the clouds, by contrary winds, meeting in a point, or a center; and where the greateſt force was exerted, there darting down, like an Archimedes's ſcrew, to ſuck up all that came in its way. Another which he ſaw, ſome time after, was attended with ſtill more terrible effects; levelling, or tearing up great oak trees, catching up the birds in its vortex, and daſhing them againſt the ground. In this manner it proceeded, with an audible whirling noiſe, like that of a mill; and, at length, diſſolved, after having done much miſchief.

But we muſt ſtill continue to ſuſpend our aſſent as to the nature even of theſe land

land ſpouts; ſince they have been ſometimes found to drop, in a great column of water, at once upon the earth, and produce an inſtant inundation *, which could not readily have happened had they been cauſed by the gyration of a whirl-wind only. Indeed, every conjecture, regarding theſe meteors, ſeems to me entirely unſatisfactory. They ſometimes appear in the calmeſt weather at ſea, of which I have been an eye-witneſs; and, therefore, theſe are not cauſed by a whirlwind. They are always capped by a cloud; and, therefore, are not likely to proceed from fires at the bottom. They change place; and, therefore, ſuction ſeems impracticable. In ſhort, we ſtill want facts, upon which to build a rational theory; and, inſtead of knowledge, we muſt be contented with admiration. To be well acquainted with the appearances of Nature, even though we are ignorant of their cauſes, often conſtitutes the moſt uſeful wiſdom.

* Phil. Tranſ. vol. iv. p. 2. 108.

CHAP. XXII.

The Concluſion.

HAVING thus gone through a particular deſcription of the earth, let us now pauſe for a moment, to contemplate the great picture before us. The univerſe may be conſidered as the palace in which the Deity reſides; and this earth as one of its apartments. In this, all the meaner races of animated nature mechanically obey him; and ſtand ready to excute his commands, without heſitation. Man alone is found refractory; he is the only being endued with a power of contradicting theſe mandates. The Deity was pleaſed to exert ſuperior power in creating him a ſuperior being; a being endued with a choice of good and evil; and capable, in ſome meaſure, of co-operating with his own intentions. Man, therefore, may be conſidered as a limited creature, endued with powers imitative of thoſe reſiding in the Deity. He is thrown into a world that ſtands in need of his help; and has been granted a power of producing harmony from partial confuſion.

If, therefore, we conſider the earth as allotted for our habitation, we ſhall find, that much has been given us to enjoy, and much

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to amend; that we have ample reaſons for our gratitude, and ſtill more for our induſtry. In thoſe great outlines of nature, to which art cannot reach, and where our greateſt efforts muſt have been ineffectual, God himſelf has finiſhed theſe with amazing grandeur and beauty. Our beneficent Father has conſidered theſe parts of nature as peculiarly his own; as parts which no creature could have ſkill or ſtrength to amend: and therefore made them incapable of alteration, or of more perfect regularity. The heavens, and the firmament, ſhew the wiſdom, and the glory of the Workman. Aſtronomers, who are beſt ſkilled in the ſymmetry of ſyſtems, can find nothing there that they can alter for the better. God made theſe perfect, becauſe no ſubordinate being could correct their defects.

When, therefore, we ſurvey nature on this ſide, nothing can be more ſplendid, more correct, or amazing. We there behold a Deity reſiding in the midſt of an univerſe, infinitely extended every way, animating all, and cheering the vacuity with his preſence! We behold an immenſe and ſhapeleſs maſs of matter, formed into worlds by his power, and diſperſed at intervals, to which even the imagination cannot travel! In this great theatre of his glory, a thouſand ſuns, like our own, animate their reſpective

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ſyſtems, appearing and vaniſhing at divine command. We behold our own bright luminary, fixed in the center of its ſyſtem, wheeling its planets in times proportioned to their diſtances, and at once diſpenſing light, heat, and action. The earth alſo is ſeen with its twofold motion; producing, by the one, the change of ſeaſons; and, by the other, the grateful viciſſitudes of day and night. With what ſilent magnificence is all this performed! with what ſeeming eaſe! The works of art are exerted with interrupted force; and their noiſy progreſs diſcovers the obſtructions they receive: but the earth, with a ſilent ſteady rotation, ſucceſſively preſents every part of its boſom to the ſun; at once imbibing nouriſhment and light from that parent of vegetation and fertility.

But not only proviſions of heat and light are thus ſupplied, but its whole ſurface is covered with a tranſparent atmoſphere, that turns with its motion, and guards it from external injury. The rays of the ſun are thus broken into a genial warmth; and, while the ſurface is aſſiſted, a gentle heat is produced in the bowels of the earth, which contributes to cover it with verdure. Waters alſo are ſupplied in healthful abundance, to ſupport life, and aſſiſt vegetation. Mountains ariſe, to diverſify the proſpect, and

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give a current to the ſtream. Seas extend from one continent to the other, repleniſhed with animals, that may be turned to human ſupport; and alſo ſerving to enrich the earth with a ſufficiency of vapour. Breezes fly along the ſurface of the fields, to promote health and vegetation. The coolneſs of the evening invites to reſt; and the freſhneſs of the morning renews for labour.

Such are the delights of the habitation that has been aſſigned to man; without any one of theſe, he muſt have been wretched; and none of theſe could his own induſtry have ſupplied. But while many of his wants are thus kindly furniſhed, on the one hand, there are numberleſs inconveniencies to excite his induſtry on the other. This habitation, though provided with all the conveniencies of air, paſturage, and water, is but a deſert place, without human cultivation. The loweſt animal finds more conveniencies in the wilds of nature, than he who boaſts himſelf their lord. The whirlwind, the inundation, and all the aſperities of the air, are peculiarly terrible to man, who knows their conſequences, and, at a diſtance, dreads their approach. The earth itſelf, where human art has not pervaded, puts on a frightful gloomy appearance. The foreſts are dark and tangled; the meadows over-grown with rank weeds; and

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the brooks ſtray without a determined channel. Nature, that has been kind to every lower order of beings, has been quite neglectful with regard to him; to the ſavage uncontriving man the earth is an abode of deſolation, where his ſhelter is inſufficient, and his food precarious.

A world thus furniſhed with advantages on one ſide, and inconveniences on the other, is the proper abode of reaſon, is the fitteſt to exerciſe the induſtry of a free and a thinking creature. Theſe evils, which art can remedy, and preſcience guard againſt, are a proper call for the exertion of his faculties; and they tend ſtill more to aſſimilate him to his Creator. God beholds, with pleaſure, that being which he has made, converting the wretchedneſs of his natural ſituation into a theatre of triumph; bringing all the headlong tribes of nature into ſubjection to his will; and producing that order and uniformity upon earth, of which his own heavenly fabric is ſo bright an example.

END OF THE FIRST VOLUME.